The N. C. Agricultural Experiment Station 1899–1900

ANNUAL REPORT NO. 23

JUNE 30, 1900

THE NORTH CAROLINA
COLLEGE OF AGRICULTURE AND MECHANIC ARTS

AGRICULTURAL EXPERIMENT STATION DEPARTMENT

GEO. T. WINSTON, LL.D., PRESIDENT AND DIRECTOR.

WEST RALEIGH, N. C.

Publications will be sent to any address in North Carolina upon application

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West Raleigh, N. C., November 1, 1900.

To His Excellency Daniel L. Russell,

Governor of North Carolina.

Sir:—I have the honor to submit the following report of the Agricultural Experiment Station of the North Carolina College of Agriculture and Mechanic Arts, for the year begun July 1, 1899, and ended June 30, 1900.

Very respectfully,

Geo. T. Winston,

President and Director.

THE NORTH CAROLINA COLLEGE OF AGRICULTURE AND MECHANIC ARTS

Agricultural Experiment Station Department,

WEST RALEIGH, N. C.

EXPERIMENT STATION STAFF.

Geo. T. Winston, LL.D., President of the College and Director.
W. A. Withers, A.M., Chemist.
B. Irby, M.S., Agriculturist.
W. F. Massey, C.E., Horticulturist.
G. S. Fraps, Ph.D., Assistant Chemist.
J. A. Bizzell, M.S., Assistant Chemist.
Alex. Rhodes, Assistant Horticulturist.
C. W. Hyams, Assistant Botanist and Entomologist.
J. M. Johnson, M.S., Assistant in Animal Industry.
B. S. Skinner, Farm Superintendent.
J. M. Fix, Bursar.
A. F. Bowen, Secretary.
Mrs. L. V. Darby, Stenographer.

The Director's office is in the main building of the College. Telephone No. 38. The street cars pass within one hundred yards of the College building.

The Station is glad to receive any inquiries on agricultural subjects. *Address all communications to the Agricultural Experiment Station, and not to individuals.* They will be referred to the members of the Station staff most competent to answer them.

REPORT OF THE DIRECTOR

OF THE

Agricultural Experiment Station

FOR THE YEAR ENDING JUNE 30, 1900.

This being the first year of my directorship, I have endeavored as far as possible to avoid changes in the lines of work and in the staff of workers, seeking to build upon existing foundations, and making only such changes and additions as seemed absolutely necessary. I found inadequate provision of land fcr agricultural and very inadequate provision for horticultural experiments, with unsatisfactory and indefinite division, between the two departments, of work-animals, tools, machines and houses. With the consent of the Board of Trustees, I assigned to the Horticultural Division of the Station the farm known as the "Experiment Station Farm," and used heretofore for agricultural experiments. It consists of ten acres, belonging to the college, and fourteen acres of adjoining land, which the college has secured for purposes of experiment. The equipment includes a commodious dwelling-house, an office and store-room, barns, tools, vehicles and work-animals. The Horticultural Division is now supplied, for the first time in the history of the Station, with suitable grounds, buildings, work-animals and machinery.

In place of the fourteen acres thus transferred to the Horticultural Division, about fifty acres of land from the college farm has been appropriated to experiments in agriculture, and the entire equipment of the college, to-wit, stock, barns and machinery, has been made available, as far as necessary, for this purpose. A seventy-five acre pasture has also been fenced in and put in shape, a long-needed and most necessary improvement. The lack of a pasture heretofore has rendered quite unsatisfactory experiments made in stock-raising, breeding, feeding, etc. The poultry yards have been moved and greatly improved. A brooder house has been erected and an incubator purchased.

We hope to procure from the State Legislature at an early date sufficient funds to erect separate buildings for the Division of Chemistry.

Additions have been made during the year to the Chemical Library, and various pieces of apparatus have been purchased.

The work of the year has been carried forward with fidelity and

energy in all the divisions of the Station. The reports of the Chiefs of the several divisions are presented herewith. A brief resume of the work is made for convenience in this report, as follows:

I. *Horticulture.*—The year has been given largely to shaping the ground, which was practically in unimproved condition. Legumes have been employed, together with stable manure, for enriching the soil.

An orchard has been planted, including 90 varieties of apple, 92 varieties of peaches, 34 varieties of plum, 14 varieties of pear, 12 varieties of cherry, 2 of chestnut, 2 of quince, and 2 of apricot. We have lost hardly a tree from the orchard. A fine growth was made during the Spring, and the orchard will be in good shape for class work and pruning.

Three hundred varieties of grape cuttings have been set out and have made good growth. They will be set in place on a hillside next to the State Fair Ground this Fall, and will be not only useful in experimenting and giving instruction to our students, but also a fine object lesson to the thousands of visitors who come annually to the State Fair.

Experiments in bulb culture have been carried on, with a view to demonstrating the profitableness of this industry in North Carolina. We have shipped about 6,000 Bermuda lilies this Fall to Northern dealers. We have a demand from one firm for 35,000 next year. We have increased our stock to such an extent that we will put them into the hands of private growers in this State for further experiment. We have also grown a large number of Narcissus. Other bulbs of the Amaryllis class have been experimented with, and we have succeeded in producing bulbs of extraordinary sizes and perfection. We hope to succeed in introducing in North Carolina on a large scale, the bulb industry.

Experiments with tomatoes have been carried on during the year with especial study of the "Southern Blight." A variety test of forcing tomatoes and a study in pollenization were made during the winter, the results being published in a bulletin. The work on tomatoes will be continued the coming winter with one variety grown under different conditions. Part of the plants will be set in soil on the bench and part will be grown in pots as heretofore. All will be hand-pollenized; and the crops compared.

Variety tests of lettuce have been made in cold frames. We shall continue these experiments the coming winter and shall also grow lettuce in one greenhouse for comparison with that grown in the cold frames.

Experiments have been made with the hope of breeding an early flowering variety of the Golden Cosmos for the use of Northern growers. These experiments will be continued the coming year.

Experiments have also been made and will be continued with the Scarlet Sage. We shall during the coming year extend the variety of ornamental annuals experimented with, hoping to introduce the industry here and improve the various strains by crossing and selection. This work of improving varieties in vegetables and in flower seeds we intend to emphasize each year.

We are hoping to obtain a variety of sugar corn which will be a success in this climate. A variety was produced by us by crossing a field corn with a sugar corn. It was a good table corn and throve well, but the grain was very shallow and the cob large, the results being, therefore, not entirely satisfactory. We shall continue experiments along this line.

During the past season we suffered very much from drouth, which interfered seriously with all our experiments. The season was quite unusual in this respect. We hope as soon as possible to make some provision for irrigation.

During the year we have added to our herbarium from exchanges 686 species of plants and have collected 150 native species. Among the native collections made by the Assistant Botanist, Mr. C. W. Hyams, are two new species, to-wit, a lily, named in honor of Professor Massey, Lilium Masseyi, and a Saururus Winstonianus.

A great number of grasses and other plants sent to us by correspondents in various parts of the State during the year have been identified and many letters of advice written in regard thereto.

In entomology about 500 specimens have been collected and by exchange with other collectors we have received 210 species. We have also identified a large number of insects sent by correspondents, and have written many letters of advice concerning the same.

The Department has been in constant communication during the year with the farmers of the State by personal correspondence. This is a work which makes little show, but accomplishes much good.

II. *Agriculture.*—Work with Cattle. Feeding experiments have been conducted with a view to ascertaining the most economical feed ration for the production of milk and for butter. These experiments will be continued the coming fall and winter. Experiments will also be made in a feed ration for beef. These experiments are conducted with such feed stuffs as are common in this State. We aim to ascertain the relative value of the different feed stuffs available for our farmers and to find how best to combine them with one another. Thorough tests for tuberculosis have been made and several animals responding to the test disposed of.

Work with Swine.—Feed tests have been made with the Poland China and Berkshire breeds. We endeavored to introduce improved breeds as widely as possible among our farmers and to ascertain the most economical feed. We shall make experiments the coming year in curing meat with a view to teaching our farmers the best methods.

Poultry.—Experiments during the past year have shown that poultry will not thrive in close confinement. Our poultry yards have been moved and we have recognized the necessity of cutting down the number of our breeds in order to give more range to the fowls. Experiments in incubation have not been satisfactory. It is hoped to tabulate results and to publish them hereafter.

Field Crops.—The work has been mainly in fertilizer and variety tests. We have tested 12 varieties of cotton, 14 varieties of corn, and 4 varieties of sorghum. Fertilizer tests were made on cotton, corn, sweet potatoes, ensilage, soiling crops, hay crops, wheat and peanuts.

Experiments have been made also and will be continued as to the exhaustion of soil by different crops, rotation of crops, and the benefit of cover crops as renovators in the winter. We have also begun an experiment in a four year rotation of the following crops: Peas, cotton, corn and soja beans, on poor, thin land, using no fertilizer, but restoring to each plot in the shape of manure that equivalent to its own yield. The purpose of this experiment is to show that worn out soil can be renewed by proper rotation of crops and returning to the soil its own yield with proper cultivation without the purchase of commercial fertilizers.

With a view to ascertaining the best forage crops for our farmers, we have made comparative tests of sorghum, corn, teosinte, pearl millet, soja beans, cow peas and velvet beans. We have also begun a series of tests with buckwheat. Fertilizer tests have been made with peanuts and a test in seed selection also. Experiments have been conducted in broom corn, and we hope to show that this can be grown profitably in our State.

The sugar beet is being tested on a small scale.

A very large correspondence has been conducted during the year with the farmers of the State, which shows that they are alive to the necessity of improvement. We are now planning to have experiments conducted under our supervision by farmers in different parts of the State; also to conduct more systematically and extensively, Farmers' Institutes; also to carry on for the benefit of farmers a summer agricultural course as well as a short winter course.

III. *Chemistry.* The chemical work during the year has been along the following lines:

1. Analysis of Sugar Beets with a view to determining the adaptability of our State to sugar beet culture. No sample grown in the State heretofore has contained as much as 13 per cent of sugar. We shall hope for better results from the present experiments.
2. Warning in regard to compost peddlers.
3. Studies in plant nutrition.

4. Digestibility of feed stuffs. The digestibility by sheep of ensilage, cotton-seed meal and timothy hay, mixed in various proportions.

5. The digestibility of proximate constituents. The results were published as part of Bulletin No. 172. The matter has been accepted for publication by the Journal of American Chemical Society.

6. Purification of Phloroglucinol.

7. Comparison of the methods for determining Proteid Nitrogen in vegetable materials.

8. Cooperative work with the Association of Official Agricultural Chemists. The analytical work has consisted of determinations in duplicate of moisture and pentosans in two samples of feeding stuffs; of moisture, humus, phosphoric acid and potash in two samples of soil; of moisture and potash in one sample of soil and of moisture and phosphoric acid in one sample of soil.

9. The Division has answered many letters of inquiry from farmers, and has endeavored to encourage the circulation and reading of agricultural books and papers.

10. *Miscellaneous.* The Division has made determinations of water, ash, ether extract, protein and proteids in two samples of mushrooms; of moisture and tannic acid in three samples of bark, and three samples of leaves; of volatile acids and saponification number in three samples of butter.

BULLETINS PUBLISHED DURING THE YEAR.

The following Bulletins have been published during the year:

No. 170.—Gardening Under Glass.

I. An Experiment in Tomato Forcing.
By W. F. Massey and A. Rhodes.

II. The Use of Glass in Gardening for the Market.
By W. F. Massey.

No. 171.—Corn Culture in North Carolina.

By B. Irby.

No. 172.—The Digestibility of Some Non-Nitrogenous Constituents of Certain Feeding Stuffs. The Purification of Phloroglucinol.

By G. S. Fraps.

No. 173.—Another Warning in Regard to Compost Peddlers.

By W. A. Withers.

No. 174.—Methods of Determining Proteid Nitrogen in Vegetable Materials.

By G. S. Fraps and J. A. Bizzell.

I deem it due to myself and the Station to say that the present year has been to some extent one of transition and rearrangement. We are getting matters in better shape in all respects than they have been heretofore.

Very respectfully,

GEO. T. WINSTON,
President and Director.

REPORT OF THE CHIEF OF THE AGRICULTURAL DIVISION.

Dr. Geo. T. Winston, *Director*.

Sir:—I herewith submit my report of the work of the Agricultural Division during the past year.

I was put in charge of the work August 3, 1899. The Agricultural Division headquarters was then at the Fair Ground Farm. My first work consisted in carrying out the work of my predecessor, which was as follows: Sheep digestion experiment; variety tests of cotton; fertilizer test of corn, cotton and sweet potatoes planted in rotation.

In October it was decided by the Executive Committee of the Board that the Agricultural Division should be moved to the College, and that the Fair Ground Farm should be turned over to the Horticultural Division, with all its equipment, horses, feed, etc., except such things as pertained strictly to agricultural work.

This arrangement went into effect in November of 1899; hence all of the work of this calendar year has been done on the College farm and in connection with the College work.

The idea was to use the College farm and its equipment for such experiment work as should be carried on, and let the Station pay a part of the running expenses, and buy such special equipment as was needed in station work proper.

This plan has worked well, as it saves running an extra farm, and concentrating all the available funds of the College and Station on one farm makes the work of that farm much more effective.

The expenses of the fiscal year 1899-1900, including salaries, were $3,711.95, against $5,265.08 for the previous year.

This amount also includes moving from one farm to another and doing some necessary building, which amounted to at least $100.

LIVE STOCK.

Work With Swine. We are testing the Poland China and the Berkshire breeds. Also these against the common or "razor back." Testing various feeds in trying to get at the most economical feed ration for hogs.

It is our endeavor to show the farmers of North Carolina that it is cheaper for them to have their smoke-houses at home than in the Northwest.

For that purpose we will also carry on some experiments in curing meat in various ways.

It will be quite interesting to find out why North Carolina hams sell in Raleigh for 12 cents per pound, when Smithfield, Va., hams sell for 18 cents. We will try to find out the remedy, and endeavor to cure the hams here so that they will be as good, or better, than the Virginia hams. This is an economic question that affects, or should affect, every farmer in North Carolina.

We should also build a model smoke-house, and not only tell the farmers what *not* to do, but show them *what* to do, and the very best method for doing it.

We will also make experiments in preparing the animal for the slaughter pen. There should be quite a difference in price between lard and bacon pork. The South was formerly noted for the quality of her bacon pork, as it was not so fat, having the protein, or lean meat, in greater proportion. We can not expect to compete with the North in lard pork, as that is preeminently the country for quantity; but we should try to balance up on quality.

Work With Cattle. So far, we have experimented with milk cattle for the most economical feed ration for the production of milk, and for butter. The results have not been published, but the work will be continued this fall and winter.

The most economic feed ration for beef will also be sought after.

We shall only experiment with such feed stuffs as are common, or should be, with most of the farmers of the State. The main idea is to get at the relative value of the different feed stuffs we have, and to find how best to combine them with each other, and in what proportions.

We have also experimented with animals that were diseased, and have made thorough test of the herd for tuberculosis. Those responding to the test were disposed of in the proper way.

Work With Poultry. The work with the poultry has not been very satisfactory, as we were limited in means, and, most of all, lost our poultryman just as the breeding season began. This can be said, however, that the Division has been put on a much more economical basis, and what work has been done has shown up very well in dollars and cents.

We have benefitted the farmers in introducing better stock, and helping by advice in their practical work.

It would be better to cut down the number of our breeds and thereby give more range to those left. This fact, if nothing else, has been clearly demonstrated, that it is useless to attempt growing chickens in close confinement. This point can not be emphasized too much. Everybody seems to know it; yet many attempt to accomplish what they know to be practically impossible.

Definite figures should be gotten up on the two methods and the contrast made striking.

FIELD CROPS.

The work with field crops has been devoted mainly to fertilizer and variety test. We have tested 12 varieties of cotton, 14 varieties of corn, and 4 varieties of sorghum.

Fertilizer tests were made on cotton, corn, sweet potatoes, ensilage, soiling crops, hay crops, wheat, and peanuts.

We are also making with the cooperation of the Chemical Department, experiments as to exhausting of soil by different crops, rotation of crops, and benefit of a renovator as a cover crop in the winter. These plats planted in cotton, corn and sweet potatoes in rotation, are also fertilized with various mixtures and single ingredients. Thus we can, after four years, form some idea as to soil exhaustion, in addition to effect of rotation crops, and renovation of soil in the winter by "cover crops." In another series we have four plots of poor, thin land, just such as may be found on most any farm.

These were planted in a four-year rotation in the following crops: Peas, cotton, corn, and soja beans. No fertilizer was used, but all the manure will go back to each plot that comes from it in the form of feed. For example, the peas were picked, and their equivalent, in the form of manure will be put back on the soil. The corn and soja beans were cut and will be fed to some animal, and the manure will be returned. The cotton seed from the cotton plot will be returned. In other words, we are experimenting to see whether our poor soils can be renewed by simply renovating crops, and by putting on manure from the feed that was taken from the land. It will be noticed from the order in which the crops are mentioned that after each exhaustive crop comes a renovator. We shall duplicate this experiment next season on newly cleared land with the purpose of finding out whether the virgin fertility of the soil can be maintained by such a system. The idea is to discover if the original fertility can be maintained on new, and regained on the old, by a system of farming which lays stress on rotation of crops, use of renovating crops, and the keeping of stock on the farm, and buying of no commercial fertilizer. If it is practicable, then we shall know it. It might be practicable, and yet not pay as well as to do the same and use commercial fertilizer in addition.

The forage crop question has also been given considerable attention. We have made comparative tests of sorghum, corn, teosinte, pearl millet, soja beans, cow peas, and velvet beans. These are crops that can be grown successfully on our North Carolina farms, and any one of them will pay handsomely. A tabulated statement will be gotten out to show their comparative values. These forage crops can either be fed green as soiling crops, or cut and cured for hay.

The teosinte, pearl millet, and sorghum were found to be excellent

for soiling crops, as they make not only a large yield of feed, but will admit of cutting three times through the season.

The velvet bean is better to plant for soiling purposes than for hay, as the vines are so long and dense that it is rather difficult to cure them. The cow pea and soja bean would of course serve the purpose as soiling crops, but answer better as a hay crop; as both make a very fine quality of hay.

Soja beans were fertilized with various mixtures to find out whether one, two or three of the essential elements would give the best results. On poor land our experiments thus far seem to indicate that best results are obtained from a complete fertilizer. It is a nitrogen gatherer, it is true, and theoretically will get what it needs from the air; but in poor land the crop does very much better when it has nitrogen in the fertilizer.

We have also begun a series of tests with buckwheat to see whether it can be grown profitably in our central and eastern sections. It is already grown successfully in the western part of the State. The crop so far is promising, and bids fair to succeed.

The peanuts are growing on a very sandy hill, and are fertilized with different mixtures, including lime, for the purpose of determining what they need, or what fertilizers will give best results.

Then we have another experiment with peanuts to determine whether there would be any special benefit from selecting the seed with large or small number of cells.

Broom corn is also being tested, and we will make estimate on cost of production, and hope to be able to give some interesting figures for the benefit of those who wish to introduce this crop. Many correspondents have written asking about its growth, etc., and as to the profit there is in growing it. These questions can be answered more intelligently after this year.

The sugar beet is being tested on a small scale, and results will be given later, when the crop is harvested. The test so far is to show whether the sugar beet can be grown profitably, and as to amount of sugar. We have several varieties planted, hence can ascertain which is the best variety for us to use.

PUBLICATIONS.

This Division has gotten out one bulletin entitled "Corn Culture in North Carolina." We have data for two more that will be gotten out in the near future.

CORRESPONDENCE.

The correspondence with farmers of the State has been quite heavy. This is a healthy indication, as it shows that the farmers

are not only waking up to their interest, but that they have confidence in the Experiment Station. They ask questions on all the various subjects pertaining to farming.

RECOMMENDATIONS.

The field work could be made very much more effective and accurate if we had a man who did nothing else but look after the field work. My assistant, Mr. J. M. Johnson, is well able to look after the Animal Industry work, and I wish to take this occasion to commend him for his faithful and efficient work.

The Farm Superintendent and Steward, Mr. B. S. Skinner, is now doing the field work, and, as far as he is able, he does well; but his time is so much taken up with other work that he can not give the attention to details that is necessary. Experiment Station work is of but little value if not carried on accurately and in detail, as the object is not money making but in getting at facts. Every piece of work that is done should be at least supervised by an intelligent, responsible person, in order to guard against mistakes.

I shall be glad when we have a thorough division of labor, with an expert in each line performing all the work.

Very respectfully,

B. Irby,
Agriculturist.

REPORT OF THE CHIEF OF THE CHEMICAL DIVISION.

Dr. Geo. T. Winston, *President and Director.*

Sir:—I have the honor to report that during the year ending to-day the Chemical Division has performed all the work which has been assigned to it by yourself or requested of it by the other Divisions of the Experiment Station. It has also planned other investigations, some of which were conducted independently, while others were conducted in cooperation with the Agricultural Division or with the farmers of the State.

More specifically the work of this Division will be considered under the following heads:

Adaptability of the State to Sugar Beet Culture. In 1877 during the first year of the existence of the Experiment Station, its Chemist distributed samples of sugar beet seed to farmers residing in different sections of the State with a view to ascertaining whether the soil and climate of the State were favorable to the culture of the Sugar Beet for the purpose of manufacturing sugar. In all the samples of beets grown in the State and sent to the Station for analysis, the percentage of sugar was found to be too low to justify the hope that the industry would prove profitable to the State under the conditions then existing.

Largely through the influence of the Secretary of Agriculture and the Chemist of the Department, sugar beet culture for commercial purposes has been introduced into several States of the Union, and the industry has developed to such proportions that there are at present in the United States 31 factories with a daily output of over 19,000 tons of sugar, and still other factories are in process of erection. Notwithstanding the fact that the previous experiments of this Station and of the United States Department of Agriculture indicated that it was hardly probable that a very large portion of the State would produce a beet containing 14 per cent of sugar, yet the success of the industry elsewhere attracted the attention of our people who were eagerly looking for crops and methods of culture for increasing the profits of the farm. So great has been the interest in the subject that a very serious effort was made (but finally abandoned) to erect on the border line of our State a large sugar beet factory. In undertaking a repetition of the experiments of twenty-two years ago, we thought that, if a beet with over 14 per cent of sugar could be produced in the State, a new industry would be opened to our people, and that if the growth of such a beet was impossible we should be able to warn our people effectually against undertaking to produce sugar beets for commercial purposes.

During the years 1898 and 1899 this Division distributed sugar beet seeds to various farmers in the State and all samples sent to us were analyzed. No sample grown in the State and sent to us contained so much as 13 per cent of sugar, and many contained much less. We can not encourage our people therefore to attempt sugar beet culture for commercial purposes. The analytical work during the past year consisted of determinations of sucrose and purity in 12 samples of sugar beets.

The results are ready for compilation and publication when the pressure of other work permits.

Warning in Regard to Compost Peddlers. Reports have reached this Division from time to time that various parties were attempting to sell to the farmers of the State formulas and so-called "farm-rights" for making composts. All such formulas which have been brought to our attention are worthless in that the constituents proposed for use do not supply the needs of the plant, and they are worse than worthless in that the farmer using them has expended his time and money and realized a very poor crop instead of a good one which might have been produced by a proper application of plant food. But even if these formulas which are sold by compost peddlers were based upon careful experiment and observation, the farmer would waste his money in paying for them because formulas carefully prepared can be obtained free of charge from various institutions supported by the State and National Government for the benefit of the farmer. A few years ago the Station issued a warning in regard to compost peddlers, and during this year has issued another Bulletin (No. 173) upon the same subject, but calling attention to additional attempts to impose upon our people.

Some Studies in Plant Nutrition. The Agricultural Division is cooperating with the Chemical Division in this experiment. This investigation was begun in the spring of 1899, but when the farm work was transferred to lands nearer the College the plats selected for this work were abandoned. The work in progress at present began in the spring of 1900. Three crops are used and these will be supplemented by a renovating crop. There will be a rotation from year to year. The plats are each one-twentieth of an acre in size, and ten are given each year to each crop. There is a variation in the quantity of fertilizer applied to the different plats. In addition to the lessons ordinarily learned from plat experiments with fertilizers we hope to study the availability of the different elements of plant food in the soil and compare the results obtained in the field with those obtained by laboratory methods. We hope also to study the minimum requirements of crops for these elements. Samples of soil have been taken for analysis at some future time. During the past year the analytical work has consisted of the determina-

tions of moisture, total soluble and insoluble phosphoric acid in one sample of acid phosphate; of total nitrogen in one sample of nitrate of soda; and of potash, sulphuric acid, and chlorine in one sample of muriate of potash.

Digestibility of Feeding Stuffs. The object of this work was to determine the coefficient of digestibility by sheep, of silage, cotton-seed meal and timothy hay mixed in various proportions. The work was begun in the spring of 1899, in cooperation with the Agricultural Division. This Division has completed its portion of the work. The analytical work during the past year consists of determinations of moisture, ash, ether extract, crude fiber, protein and proteids in four samples of feeding stuffs, three samples of waste and six samples of excrements.

Digestibility of Proximate Constituents. This work was begun during the summer of 1899. It is customary in feeding experiments to determine the percentages of moisture, ash, ether extract, crude fiber, protein and proteids in the feeding stuff and in the excrement, and to consider the difference as digestible. Each of these classes of substances is made up of substances which differ very much in digestibility. This Division thought that it would be valuable to know the amounts of the different groups of substances forming these different classes in the feeding stuff and in the excrement. The work thus far has included only the non-nitrogenous constituents. In the nitrogen-free extract has been determined the digestibility of the sugars and pentosans, and with the aid of determinations by others, has been calculated the digestibility of the remainder after taking out the sugar, starch and pentosans. In the crude fiber was determined the digestibility of pseudo-pentosans and the remainder of the crude fiber. As a result of this work the digestibility of these substances is placed in the following order, viz: Sugar, starch, pentosans, remainder of the nitrogen-free extract, crude fiber not pseudo-pentosans, pseudo-pentosans in crude fiber. This work would emphasize the importance of making determinations of sugar, starch, and pentosans even if that of crude fiber were omitted. The analytical work during the past year has consisted of determinations of moisture and pentosans in fifteen samples of feeding stuffs, ten samples of waste, and twenty samples of excrements; of sucrose and glucose in thirteen samples of feeding stuffs and eight samples of excrements; of pentosans and crude fiber in ten samples of feeding stuffs, three samples of waste, and sixteen samples of excrement.

The results of this work were published as a part of Bulletin No. 172. The matter has been accepted for publication by the Journal of the American Chemical Society.

Purification of Phloroglucinol. In making a determination

of the amount of pentosans in feeding stuffs it has been customary to use chemically pure phloroglucinol, which is a very expensive article. This Division has devised a method for the purification of the commercial article so as to give a satisfactory product costing only about one-sixth as much as the chemically pure substance. The description of the work and the method recommended has been published as a part of Bulletin No. 172, and has been accepted for publication by the Journal of the American Chemical Society. The analytical work has consisted of six determinations of pentosans in three samples of feeding stuffs; and of the determinations of the solubility of one sample of phloroglucinol in hydrochloric acid.

A Comparison of the Methods for Determining Proteid Nitrogen in Vegetable Materials. Several methods are in use for this determination and the results by the different methods do not agree. As a result of the work of this Division it has been found that the Stutzer method and the phospho-tungstic acid method modified by this Division give closely agreeing results. The bromine method for vegetable materials appears of doubtful value. The analytical work consisted of fourteen determinations of the total amount of nitrogen; fifteen determinations of proteid nitrogen by the bromine method; sixteen determinations made in duplicate by the phospho-tungstic acid method; sixteen determinations by the Stutzer method; four determinations by the zinc sulphate method; and four determinations of diffusable nitrogen.

A discussion of the work has been published as Bulletin No. 174, and accepted for publication by the Journal of the American Chemical Society.

Cooperative Work With the A. O. A. C. The Association of Official Agricultural Chemists has been engaged for several years in devising and improving methods for agricultural analysis. Samples of various materials are sent out each year to the members of the Association by the referees in order that existing or proposed methods may be tested. This Station has cooperated in the work from the formation of the Association. The analytical work during the past year has consisted of determinations in duplicate of moisture and pentosans in two samples of feeding stuffs; of moisture, humus, phosphoric acid and potash in two samples of soil; of moisture and potash in one sample of soil and of moisture and phosphoric acid in one sample of soil.

Correspondence. This Division has been glad to answer promptly such letters of inquiry as have been received from the farmers of the State relating to agricultural matters. In this correspondence we have endeavored to encourage the reading of some of the many excellent agricultural books and papers now in existence.

Miscellaneous. During the past year this Division has made

determinations of water, ash, ether extract, protein and proteids in two samples of mushrooms; of moisture and tannic acid in three samples of bark, and three samples of leaves; of volatile acids and saponification number in three samples of butter.

In closing, the writer desires to express his satisfaction with the work of Dr. Fraps and Mr. Bizzell, Assistant Chemists, and to acknowledge his appreciation of the courtesies received at the hands of the Director.

Very respectfully, W. A. WITHERS,
Chemist.

REPORT OF THE CHIEF OF THE DIVISION OF HORTICULTURE, BOTANY AND ENTOMOLOGY.

Dr. Geo. T. Winston, *Director.*

I beg leave herewith to submit the report of the Division of Horticulture, Botany and Entomology for the year ending June 30, 1900.

HORTICULTURE.

Since the Horticulturist of the North Carolina Station has never had until the fall of 1899 any land at his disposal and control for outdoor experimentation, there is but little to report in the way of results. Last summer, the whole of the old Station farm was finally assigned to me for work in horticulture, and the past year has been entirely a year of preparation for work. The fall and winter were largely spent in the shaping of the grounds.

The old and dilapidated fence along the public road has been replaced with a Page woven wire fence, and a neat iron gate-way has been added, so that now the front of the grounds is open to the public view. The poultry yards have been removed to the College grounds, and the line of the entrance road has been changed to a better location. The lands next the Fair Grounds which have been taken in by the change in the entrance and the straightening of the fence, were in a very unimproved condition, a heavy and very hard clay. On this piece peas were sown this spring for the purpose of improving the soil and accumulating humus to mellow it for use. It is intended to follow up these with the growth of other legumes until the soil is in a fit condition for vegetable or fruit culture. The small orchard which had been planted on part of this land about fourteen years ago had by neglect become very unsightly, and some of the trees were infested with scale. Then, too, all record of the varieties had been lost, and as the orchard could serve no good purpose in experimental work, it was dug up and burned. As funds available for Horticultural experiments were very small I made an appeal for help to the Nurserymen of the State, who very cordially responded, and sent us for planting last fall specimens of all the fruit trees they cultivate. This was especially true of Messrs. J. Van Lindley, of Pomona, N. C., and John A. Young, of Greensboro, N. C.

Through the liberality of these gentlemen we were able to plant one hundred and twenty apple trees in ninety varieties, one hundred and forty peach trees in ninety-two varieties, forty-nine plum trees in thirty-four varieties, twenty-three pear trees in fourteen varieties, twenty-one cherry trees in twelve varieties, two chestnuts of two

varieties, the Mammoth Japan and Paragon, and two quince trees, one each of Champion and Meech.

The varieties of peaches are as follows:

Big Leaf, Davis Cling, Bordeaux Cling, Tippecanoe, Orange Free, Hawkins Winter, Iron Mountain, Greensboro, Preston Cling, Heath Cling, Bilyeu's October, Yellow Davis, Stump the World, Butler's Late, Keyport Red Cling, Miss Solo, Belle of Georgia, Snow, Chair's Choice, Old Mixon Cling, Old Mixon Free, Fleiter's St. John, Bray's Rareripe, West's Late Yellow, Krummel's October, Mountain Rose, Haynes's Surprise, Cowper's Late, Alexander, Piquet's Late, Lord Palmerston, Pool's Favorite, Nettie Corbet, Captain Ede, Lady Ingold, Elberta, Ira Eagle, Alton, Fluellen Cling, Mamie Ross, Jessie Kerr, Early Michigan, Nettie Lyon, Bishop, Worth, Gold Dust, Family Favorite, Fitzgerald, Salway, Albright's October, Crawford's Late, Reeve's Favorite, Stonewall Jackson, Hill's Chili, Bokara No. 3, Indian or Blood Cling, Levy's Late or Henrietta, Governor Briggs, Emma, Stonewall Jackson Cling, Waddell, Wheatland, Matthews Beauty, Eaton's Gold, Chinese Cling, Carman, White English Cling, General Greene, No. 10, Gary's Hold On, Scott's October, Early Rose, Triumph, Alice Haupt, New Prolific, Beer's Smock, Wonderful, Sneed, Thurber, Stevens's Rareripe, Connett's Early, Crawford Early, Crosby, Champion, Ford's Late, Golden Drop, Eureka, Klondyke, Globe, Admiral Dewey, Crother's Late, Everbearing.

The following varieties of apples were planted:

Mattamuskeet, Painted Lady, Hanes Seedling, Biggerstaff, Carter Blue, Winslow, Arkansas Beauty, Hunge, McCuller's Winter, Early Strawberry, Maiden Blush, Shockley, Buckingham, Kinnard's Choice, Bismark, Yates, Red Siberian Crab, Stayman's Winesap, Early Colton, Red June, Nansemond Beauty, Scotch Red, Transcendant Crab, Rebel, Grimes Golden, Starr, Early Harvest, Dartmouth Crab, Yellow Siberian Crab, Summer Rose, Dutch Winsington, Lady, Van Hoy, Summer Green Skin, Virginia Beauty, Horse, Pine Stump, Broadnax, Neverfail, Paragon, Delaware or Lawder, Edwards, Kernodle's Winter, Shenango, Hales, Early Cluster, Gregory, York Imperial, Summer Pearmain, Yellow May, Yellow Transparent, Bonum, Red Astrakan, Drab, Oliver's Red or Coulton, Robinson's Winter, Summer, Arkansas Mammoth Black, Romanite, Hall Seedling, Gulley, Ingram, Dudley's Winesap, Red Hubb, Wader's Juicy, Carolina Winter, Arkansas Neel, Col. Aldrich, Perrie's Winter, Royal Limbertwig, Northern Spy, Winter Paradise, Winter Banana, Farthing's No Bloom, Large Red and Green, Winesap, Fallawater, Baldwin, May, Troy, Early Yellow, Haas, Vandevere, White Winter Pearmain, Gloria Mundi, Ben Davis, Red Limbertwig, Mammoth Black Twig, Russet, Salome, Beauty of the World, Grier, Summer Queen, Gibson's Best, Clark's Pearmain, Clarke's Beauty.

In addition to these there were a number planted with which no label was received, and which are therefore for future identification.

PEARS.

Kieffer, Early Harvest, Prince's St. Germain, Beurre D'Anjou, Toye's Sugar, Wilder's Early, Vermont Beauty, Garber, Koonce, Duchesse d'Angouleme, Lincoln Coreless, Seckel, Le Conte, Lucy Duke, Dean, Bartlett, Japan Golden Russet, Crisco, Conkleton, Alice Payne, Early Green Sugar, Flemish Beauty, and a few others for which no label was found.

CHERRIES.

Early Purple Guigne, English Morello, Early Richmond, Reine Hortense, Common Morello, Governor Wood, Ostheime, Empress Eugenie, Dr. Wiseman, Red Ripper, Hoke, Montmorency, Abesse Duke, Olivet, May Duke, Dye House, Black Tartarian, Napoleon Biggareau.

PLUMS.

Forest Rose, Wild Goose, Apple Plum, Yellow Wild Goose, Kelly, Mrs. Clifford, Ogon, Wickson, Willard, Golden Beauty, World Beater, Tennant Prune, Normand, Hale, Paragon, Stork Green Cage, Berckmans, Chalco, Bailey, Climax, Kelsey, Chabot, Satsuma Blood, Red June, White Kelsey, Sweet Damson, Mikado, Common Damson, America, Excelsior, Burbank, Simoni, Apricot Plum, Kerr, Shropshire Damson, Abundance, Gold, German Prune, Davy Crockett, Yeddo, Spaulding, Ohio Beauty.

There were also a number of plum labels lost.

APRICOTS.

Gold Dust and Bergman.

We also planted a few trees of Japan Walnut, Paragon Chestnut, Champion Quince and Meech Quince.

We were very fortunate to lose hardly a tree, and the young orchard has made a fine growth during the spring, and will be in good shape in the fall for class work in pruning.

Through the kindness of Prof. Quintance, of the Georgia Experiment Station, we were supplied with cuttings of three hundred varieties of grapes. These were set in the open ground, and have grown well and will give us an abundant supply of plants to be set in the experimental vineyard this fall, and as they will be set on the hillside next the State Fair Grounds they will form an object lesson in pruning and training at least to the visitors at the Fair. They will also be of great use to us in experimenting with different modes of training and cultivation, and as lessons for the students. We hope

to make illustrations of all the chief methods of pruning grapes, and to make this vineyard of great value to the growers interested, as we not only purpose to study the adaptation of the varieties to our use but their adaptability to different methods of treatment with fertilizers.

EXPERIMENTS IN BULB CULTURE.

The experiments inaugurated heretofore in the culture of the various bulbs used so largely for winter forcing by florists, and which have heretofore been imported from France, Holland, Italy and Bermuda, have been continued with some success. We have given especial attention to the production of Lilium Harrisi, commonly known as the Bermuda Easter Lily. The prevalence of disease in Bermuda has caused a general effort on the part of the importers of these bulbs to find a place where they can be grown with success in this country. Messrs. Peter Henderson & Co., of New York, have been very active in this matter, and through their liberality we have been able to make a large planting of the lilies. They sent us last fall 20,000 bulbs. Unfortunately they were received late in December, and from having been kept so long in the packing boxes they had started to make long white shoots. This required us to plant then quite deeply so as to protect these shoots from the cold. They grew well, and bloomed finely, but on lifting them we found that the deep planting had caused them to form a mass of bulblets above the main bulb, which had weakened the main bulb, so that we had but about 6,000 which we considered good enough to ship to New York, and for which the Station was paid. This has given us, however, a large number of sets for planting this fall, a large part of which will be placed in private hands for further experiment in the hope of starting the industry here. We have also grown a large number of the Narcissus, and have produced good bulbs. Since the Bermuda lily is annually imported to the extent of nearly a million dollars, it is evident that if we succeed in producing them here a profitable industry can be inaugurated. Other bulbs of the Amaryllis class have been experimented with and bulbs of extraordinary size and perfection have been produced. The old Easter lily of the gardens we have also grown to great perfection, and have shipped in past years some of them to New York, which were pronounced the finest ever seen there. We find, however, great difficulty in getting up a stock of these as they do not increase as the Bermuda lilies do. A year ago some of these we sent to Philadelphia were sold at double the price of the French imported bulbs. If we can succeed in propagating them rapidly there is no doubt that they can be grown here to great perfection. We propose to continue the investigation, and hope for success.

EXPERIMENTS WITH TOMATOES.

The greatest drawback to the culture of the tomato in the South is the bacterial blight, commonly known as "Southern Blight." When the soil of any locality becomes infested with these bacteria it is almost impossible to grow tomatoes in it at all. We had a piece of garden land which is badly infested. Last year we applied a coat of lime to the soil and planted tomatoes, planting at same time a check plot alongside without lime. This was in my private garden, since the Horticulturist of the North Carolina Station had then no garden ground. The result was that on the limed plot I had no blight, while on the unlimed plot the plants all died with the disease. The same two plots were planted again this season with no further liming. The result was that both plots died from blight. It seems evident then that whatever effect the lime may have had was but temporary, and that if any prevention is thus secured it must be kept up as often as the land is planted in tomatoes. The safest way, however, is to plant in land that for some years has had neither tomatoes, egg plants or potatoes planted on it since all of these are subject to the same disease.

This spring we planted two plots at the Station farm, one of which was limed and the other unlimed. But this was on land which has never before probably borne a crop of tomatoes or allied plants, and the result will be of little avail. There was no blight up to June, but the heat and drought was destroying the plants, and by the last of June all were about dead. This Division is without any means whatever for irrigating anything, and when drought of great intensity comes any experimental work must suffer. We applied last summer for means to erect a tank for watering part of the ground, but it was not allowed. A variety of experiments was made with the various musk and watermelons grown so largely by our gardeners, but the same cause, drought and heat, made the experiment worthless.

LETTUCE.

The winter crop of lettuce has become one of the most important crops to our markets gardeners, and there is a general desire to get the variety best adapted to their needs. We have therefore been making a variety study of lettuces for two seasons past in the frames near the Primrose Hall. The first season's results have already been published in a bulletin. We will continue this work during the next winter, and will again publish the results hoping for something that may help the commercial growers. Already we have found that they are growing with success the variety we found best in the first experiment. We will also make selections and grow seed

for further trial hoping to develop a variety better adapted to our needs than any now grown.

WORK UNDER GLASS.

Aside from keeping a collection of plants convenient for botanical study and for decorative purposes, we have used our glass structures to some extent for experimental work. A variety test of forcing tomatoes, and a study in pollenization were made during the past winter, the results of which have been published in a bulletin. The work on tomatoes will be continued the coming winter with the same variety grown under different conditions. Part of the plants will be set in soil on the bench, and part will be grown in pots as heretofore. All will be carefully hand-pollenized and the crops compared. In addition to the variety test of lettuces in the frames, we propose to use one cool greenhouse for the growing of lettuce in the manner practiced in the North, for the purpose of noting the difference in the quality of the product with that grown in the simple cold frame, so as to be able to advise our growers as to the practicability or profitability of growing the crop in this way. The house selected for this purpose is so arranged that the hot water heat can be almost entirely cut off from it during moderate weather, while at the same time the tropical houses can be heated to their full need. Part of the same house will be used for radishes, and for carnations and other ornamental stuff needing a low temperature.

During the past winter this house had in it a collection of plants that required some heat, and the consequence was that carnations and other things needing a low temperature, did not do as well as they should.

SEED GROWING.

The fact that in Georgia and elsewhere in the South there are a few parties who are making a success in the production of seed of late flowering ornamental plants, which can not be well grown in the North, has led me to make some experiments with a few ornamental plants in demand with the Northern dealers. A new and striking variety of cosmos, known as Klondyke, with flowers of a golden orange color, was produced by a gentleman at Americus, Georgia. The plant is a wonderful bloomer, but flowers too late to be of any use to the growers in the North in the open ground. A few of our plants last season bloomed very early and continuously during the summer, and we have planted a lot of them with the hope of breeding an early flowering variety for the use of the Northern growers. A few plants of these made flowers early in the season and have been marked for future experiment, and seed will be taken only from these. The drought has severely tried the plants, but we hope for success hereafter.

Salvia Splendens, commonly known as Scarlet Sage is a very popular bedding plant, and rarely seeds well in the North because it there blooms too late. We grew a large lot of plants of the best varieties, and made arrangement to supply seed of them to two Northern dealers at a price that would pay our growers very well, but the dry weather and great heat has made havoc of the plants and we have informed the firms dealt with that they can this season depend on us for very few seeds. The land in which these were planted was not well adapted to the purpose, being the hard red clay fill about my building. I purpose to continue the experiment under better conditions another season, and not only to produce seeds but to improve the varieties by selection from the most floriferous and sturdy plants. It is my intention to extend the variety of ornamental annuals experimented with, and thus make an effort not only to introduce the industry here, which has developed to large proportions in California, but to improve the various strains by crossing and selection.

It is my purpose to make this improvement of varieties in both vegetable and flower seeds a leading part of the work of this Division. There is a wide field for effort in this line, and a great and growing demand for such work, and in no way can the Horticultural work be made of greater use to the growing horticultural interests of the State.

One of the greatest difficulties which besets our gardeners is to get a variety of sugar corn which will be a success in this climate. In past years we made an effort to produce such a variety by crossing a field corn with the sugar corn. We succeeded in getting a corn that throve well here, and was a good table corn, and which showed that the sweet corn can be acclimated and thrive well here. But this corn had defects, in a very shallow grain and large cob, and a year ago we distributed all the seed we had and notified the planters that we would have no more. We wish now to start with the selection of a pure sugar corn having as near as possible the characters we wish to fix, and hope to be able to get a variety without the defects the Station corn has had heretofore. In brief, we will work continually in the improvement of all the plants grown by our market and private gardeners, and endeavor to make our work of real practical importance to them.

BOTANICAL.

The work in Systematic Botany has been largely in the hands of my assistant, Mr. C. W. Hyams. Our Herbarium was begun but two years ago with a collection made by Mr. Hyams in the mountains of the State. With the large collection he made at that time, we have been able to make exchanges with other institutions and botanical

collectors, and the collection is growing in size and interest, and forms a valuable means for study and the identification of specimens sent in.

We have added during the year to the herbarium collection through exchanges with others, six hundred and eighty-six species of plants, and have collected one hundred and fifty native species.

Among the botanical collections of the past year, Mr. Hyams has collected two species new to botanists. One of these is a new lily, collected in the mountains of western North Carolina, which he has named in my honor, Lilium Masseyi. The other new plant is a Saururus, which has been named in honor of the President Saururus Winstonianus.

I have during the year identified a great number of grasses and other plants sent to us by correspondents in various parts of the State, and have written letters of advice in regard to the agricultural value of these grasses. We have received for the Division library a donation of 50 botanical papers relating to the Southern Flora, from Dr. J. K. Small, of Columbia College, New York.

ENTOMOLOGY.

In this section of our work the principal effort has been to begin the formation of a collection for study and comparison for the identification of specimens sent in, and for study of their characters. About five hundred specimens have been collected, and by exchange with other collectors we have received two hundred and ten other species. We have also identified a large number of insects sent in by correspondents, and have given letters of advice in regard to them, telling how best, so far as is known, the injurious ones may be destroyed, and how the beneficial ones may be encouraged.

One part of the work of the Horticultural Division, which I consider of very great importance, but which makes little show on the surface, though taxing my time and study to the utmost, is the correspondence that has grown up with the farmers of the State. The keeping up with this correspondence is the larger part of the labor that devolves upon me individually. As I have no assistance whatever from a stenographer or a typewriter, I have to keep up all this work with my own hands on the machine. I have in years past encouraged the farmers to write us, and have promptly answered all their letters, giving them all the help in my power, and in this way I believe that I have been instrumental in bringing the Station more into sympathy with the tillers of the soil, and have been able to gain their confidence and help them. But the writing of the thousands of these letters is labor that takes a great deal of time, and occupies every moment of time I can spare from College and Station work

outside. But I do not know how the Station can be of greater practical use to the farmers of the State than by helping them in the solution of the problems that beset them. We are daily receiving evidence that the farmers of North Carolina are appreciating the work of the Station more and more. Of course this is not investigation work, but it is a compliance with that part of the law which requires the Station to diffuse information.

Respectfully submitted, W. F. Massey,
Horticulturist, Botanist and Entomologist.

Financial Statement of the North Carolina Agricultural Experiment Station for the Year Ending June 30, 1900.

RECEIPTS.

From the Treasurer of the United States (Hatch Fund)	$15,000.00
" " sale of farm products	420.87
" miscellaneous sales	1,438.04
Total receipts	16,858.91

Expenditures.	Hatch Fund.	Farm Products.	Miscellaneous.	Total.
Salaries	$9,577.01			$9,577.01
Labor	1,441 88	$315.00		1,756.88
Publications	1,574.46		$348.75	1,923.21
Postage and stationery	245.04	14.93		259.97
Freight and Express	70.63		.64	71.27
Heat, light and water	10.71	11.04		21.75
Chemical supplies	356.12	79.33		435.45
Seeds, Plants and sundry supplies	167.51	.57	14.43	182.51
Fertilizers	112.00			112.00
Feeding stuffs	515.64		50.32	565.96
Library	94.20		154.28	248.48
Tools, implements and machinery	288.54		383.85	672.39
Furniture and fixtures	131.98		168.75	300.73
Scientific apparatus	178.67			178.67
Live stock	7.60			7.60
Traveling expenses	72.60		79.00	151.60
Contingent expenses	20.06		105.59	125.65
Building and repairs	135.35		132.43	267.78
Total expenditures	15,000.00	420.87	1,438.04	16,858.91

We, the undersigned, duly appointed Auditors of the Corporation, do hereby certify that we have examined the books and accounts of the North Carolina Agricultural Experiment Station for the fiscal year ending June 30, 1900; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $15,000.00, and the corresponding disbursements $15,000.00; for all of which proper vouchers are on file and have been by us examined and found correct, thus leaving nothing.

And we further certify that the expenditures have been solely for the purposes set forth in the Act of Congress approved March 2, 1887.

(Signed) Jno W. Harden, Jr.,
J. B. Stokes,
Auditors.

(Seal.)

Attest: J. M. Fix, *Custodian.*

Bulletin No. 170 March, 1900

THE NORTH CAROLINA

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

AGRICULTURAL EXPERIMENT STATION DEPARTMENT

GEO. T. WINSTON, A.M., LL.D., Director

Gardening Under Glass

I. An Experiment in Tomato Forcing.

By W. F. Massey and A. Rhodes.

II. The Use of Glass in Gardening for the Market.

By W. F. Massey.

WEST RALEIGH, N. C.

Publications will be sent to any address in North Carolina upon application.

THE NORTH CAROLINA COLLEGE OF AGRICULTURE AND MECHANIC ARTS

AGRICULTURAL EXPERIMENT STATION DEPARTMENT

WEST RALEIGH, N. C.

EXPERIMENT STATION STAFF.

GEO. T. WINSTON, A.M., LL.D., President of College and Director.
W. A. WITHERS, A.M., Chemist.
BENJ IRBY B.S., Agriculturist.
W. F. MASSEY, C.E., Horticulturist, Botanist and Entomologist.
G. S. FRAPS, Ph.D., Assistant Chemist.
J. A. BIZZELL, B.S., Assistant Chemist.
ALEX. RHODES, Assistant Horticulturist.
C. W. HYAMS, Assistant Botanist and Entomologist.
J. M. JOHNSON, M.S., Assistant in Animal Industry.
B. S. SKINNER, Farm Superintendent.
J. M. FIX, Bursar.
A. F. BOWEN, Clerk and Secretary.
MRS. L. V. DARBY, Stenographer.

The Director's office is in the main College building. Telephone No. 38, Interstate line. The street cars pass within one hundred yards of the College building. The members of the Station Staff are always at the service of the farmers of the State to answer any inquiry connected with their work.

LETTER OF TRANSMITTAL.

N. C. College of Agriculture and Mechanic Arts.
Experiment Station Department,
Division of Horticulture, Etc.

Dr. Geo. T. Winston, *President and Director.*

Dear Sir:—I beg herewith to submit for publication a manuscript giving an account of the experiment made during the winter just past in testing the respective values of a number of varieties of tomatoes for forcing under glass in winter.

There is a great increase of interest among our market gardeners, especially in the eastern part of the State, in winter gardening. I have therefore added some hints on the use of glass on frames and in temporary greenhouses, hoping in the future to deal with the subject of Winter Forcing in the South in a more exhaustive way.

Trusting that the Bulletin may aid some who are now struggling with difficulties in gardening, I am

Very respectfully,

W. F. Massey

Horticulturist, etc.

Winter Forcing of Tomatoes.

By W. F. Massey and A. Rhodes.

INTRODUCTORY.

The work detailed in the following pages is a continuation, to some extent, of experiments in the winter forcing of tomatoes that have been in progress for the past three seasons. The main difference in the work the past winter and that of the previous winters has been that during this season it has been a study of the adaptability of varieties for this purpose, and also, a study of methods of pollenation.

Heretofore the object has been to ascertain the practicability of the culture here as a commercial matter. That is, whether the forcing of tomatoes can be made a profitable business.

It has been evident from the former tests that with houses built especially for the purpose, and better adapted to forcing than the houses we have used, there will be a fairly profitable business. That a man engaged in a general floricultural business can profitably use a portion of his glass for winter forcing until the advancing spring season requires the use of all the glass for the production of bedding plants for his spring trade. Managed in this way, the florist could grow tomatoes and beans and strawberries very profitably during the part of the season when he did not need the use of all his glass. Of course it would be a question of individual conditions, for it may pay the florist to use the glass for forcing cut-flowers rather than tomatoes, and one so situated would of course grow that which is most profitable under his conditions. But there are many so situated that the cut-flower trade is of little importance to them, and yet who are favorably located for shipping winter forced vegetables.

There are few large towns where a local trade of this sort can not be easily established to a certain extent. Grown to the extent we have grown them, the tomato crops during the winter can be profitably disposed of in the local market, and there is not a large town in the State where the same thing can not be done to a limited extent.

There are always in such places a few people who are willing to pay a fair price for a good article, and we have found no difficulty in disposing of tomatoes in direct competition with the Florida product at a far better price, because of the superior quality of the product grown under glass.

VARIETIES TESTED.

The object of the experiment being to determine the respective value of different varieties of tomatoes for winter forcing, a number of sorts were planted. The seeds were all sown the same day, and in every respect the plants had the same treatment. The following varieties were planted: Matchless, Perfection, Maule's Imperial, Maule's New Forcing, Stone, White's Excelsior, Fordhook Fancy, Purple Advance, and Maule's Earliest.

The most popular tomato for winter forcing has been the Lorillard. In previous experiments we grew this variety and the Dwarf Champion with the result that in our method of growing, the Dwarf Champion invariably gave the best results. With a different method of culture the case might have been reversed, since all our forcing has been done in ten-inch flower pots. In the test made of a few varieties in 1898-99, the Essex Hybrid gave the best results as a cropper, and also in the smoothness and perfect setting of the fruit.

THE FORCING HOUSE.

The house used for these experiments is part of the range of glass at the college, and consisted of a house 20 x 60 feet. It is an even span house, running north and south. The house is supplied with an abundance of hot-water piping, so that, if necessary, a night temperature of 70 degrees can be maintained in the coldest weather, though this temperature is not needed in tomato forcing, the usual night temperature used being from 55 to 60 degrees. The whole house was devoted to tomatoes, but the plants used in the variety test occupied the middle bench alone.

Twelve plants of each variety were grown for the comparison.

METHOD OF CULTURE.

The seeds were sown in flats September 5, 1899, and potted into three-inch pots as soon as large enough to handle. When well

established in these pots they were transferred into four-inch pots, and from these into the fruiting pots of ten inches. The soil used was a mixture of one-half our ordinary potting compost and one-half Jadoo fibre.

The Jadoo fibre is a newly invented potting material made by steaming peat moss with chemicals, forming a black, fibrous mass that retains moisture well, and has a good mechanical effect when mixed with the potting soil, favoring the development of the root system to a remarkable degree. It was used mainly for its mechanical effect as there is great difficulty here in getting good turf for potting compost, and some mixture of fibrous material with the earth we are compelled to use is a great advantage.

In transferring the plants from the four-inch pots into the ten-inch ones, care was taken to supply an abundance of drainage by placing crocks in the bottom and covering them with the Jadoo fibre. The compost was then filled in only to the height of the four-inch ball. As soon as new roots could be discerned penetrating the fresh compost, an additional layer of the compost was given, an inch thick. Thereafter successive layers were added as fast as new roots appeared in the last layer, until the pots were sufficiently filled.

Managed in this way the plants developed a great mass of roots, and were soon completely filling the ten-inch pots, and in this condition were in shape to take up additional nourishment, which was given by watering with liquid fertilizer made from the Jadoo liquid, reinforced with a small quantity of nitrate of soda.

The plants were trained strictly to a single stem, each being trained to a reed stake stuck in the pot and attached at the top to horizontal reeds so as to make a stiff trellis.

In previous experiments this house has been found badly infested with Cladosporium fulvum, which the winter before destroyed nearly all the foliage, and made the result of no value. Therefore special effort was made this season to prevent the attack of the fungus, as it was found totally impracticable to get rid of it when once in. The plants were sprayed with sulphide of potassium in a weak solution, and the hot-water pipes were painted over with a wash of lime and sulphur. There was a strong sulphurous odor at times in the house,

when firing was going on, and there was no appearance of the fungus on any plant in the house.

It is believed that the lime and sulphur that was on the pipes will of itself prevent the development of fungus, but in order to prevent an attack before the weather is cold enough to fire the boilers, it is well to use the sulphide one ounce to two gallons of water.

Care should be used in spraying, as the chemical will blacken white paint wherever it touches it. Prevention should always be the rule in combatting fungus disease in any plant, for after the invasion has gone so far as to develop the fruiting spores, the case is beyond help.

Our complete freedom from disease the past winter in a house badly infested the winter before, shows the importance of prevention.

VARIOUS METHODS OF FORCING.

We have used flower pots for forcing tomatoes, because it was not practicable to arrange our houses for planting out in soil on the benches. In most cases this planting in beds of soil on the bench is practiced. Others use large wooden boxes for growing the plants. We have in past years tried both of these plans, but under the conditions in which we are compelled to work, we prefer to use the ordinary earthenware pots. The bench on which the pots stand is covered an inch or more deep with coarse sand. This not only assists in the free drainage of the pots, but helps to preserve moisture in the air, since syringing overhead is impracticable with tomatoes, and yet moisture must be maintained in the house to keep down the red mites, which would soon destroy every leaf in an arid atmosphere.

Plants grown in pots require closer attention to watering than those in boxes or on the bench, but this makes the culture a valuable help to the young men who were engaged in the work, in the study of moisture conditions and proper watering under glass.

RESULTS.

Being not only a variety test, but a study of methods of pollenation, the total crop was not as large as it might be made by an exclusive growth of a variety well adapted to forcing, and the use of the best method of setting the fruit. The table shows the amount of fruit gathered each day from each variety.

Number of plants in each case 12.

Variety.	Dates of Gathering.		Weights. Lbs.	Weights. Oz.
MATCHLESS	January	26	....	9½
	February	3	3	12
	"	10	1	2
	"	14	2	12
	"	20	....	7
	"	24	....	12
	March	1	....	7
	"	9	....	6½
	"	14	....	13
	"	22	1	7
Total	....		12	8
MAULE'S IMPERIAL	January	13	....	3½
	"	18	1	1
	"	26	4	9½
	"	30	....	5½
	February	3	2	3½
	"	8	....	15½
	"	9	....	9
	"	10	1	10½
	"	14	2	7
	"	24	....	12½
	March	9	....	11½
Total	....		15	10
PERFECTION	January	13	....	12
	"	18	1	12½
	"	20	....	4
	"	26	1	4
	February	3	1	10½
	"	9	2	9
	"	10	1	1
	"	14	1	10
	"	24	....	2
	March	1	....	6
	"	14	....	6
Total	....		11	13
MAULE'S NEW FORCING	January	18	1	11½
	"	20	1	3
	"	26	3	15½
	February	3	1	10
	"	10	1	9¼
	"	14	2	14½
	"	20	1	6½
	"	24	....	6½
	March	9	1	3
	"	14	....	13¼
	"	22	....	10
Total	....		17	6

Variety.	Date of Gathering.		Weights. Lbs.	Oz.
Stone	January	13	....	1¾
	"	18	3	1½
	"	20	1	5
	"	26	4	5½
	"	30	......	9½
	February	7	....	15
	"	10	2	2¼
	"	14	1	5
	"	20	....	4
	March	1	1	1
	"	9	1	7
	"	14	....	5½
	"	22	......	6
Total	....		17	12
White's Excelsior	January	13	....	2¼
	"	18	2	9¼
	"	20	1	5
	"	26	3	15
	"	30	1	....
	February	3	1	10
	"	10	1	10
	"	14	1	7
	March	1	....	11
	"	9	....	14½
	"	14	....	10
Total	....		15	14
Purple Advance	January	9	....	15
	"	13	1	11
	"	18	2	2
	"	20	2	3
	"	26	1	6
	"	30	....	1
	February	3	2	4
	"	10	....	9
	"	14	....	5
	"	20	......	12½
	"	24	1	5
	March	1	....	9½
Total	....		13	7
Fordhook Fancy	January	13	....	4½
	"	18	2	10½
	"	20	1	....
	"	26	5	5¼
	"	30	......	3½
	February	10	......	6
	"	14	....	4½
	"	20	....	6½
	"	24	.....	4
	March	2	....	13½
	"	9	....	5
	"	14	1	2½
	"	22	......	6½
Total	....		13	8

Variety.	Date of Gathering.	Weights.	
		Lbs.	Oz.
MAULE'S EARLIEST	December 25	....	12
	January 9	2	7½
	" 18	2	10
	" 20	3	14½
	" 26	4	12
	" 30	....	5
	February 3	2	2
	" 10	2	4
	" 14	1	1
	" 24	....	2
	March 1	1	2
	" 9	....	4½
	" 14	....	10½
Total	....	22	7

DESCRIPTION OF VARIETIES.

Matchless.—A large and showy tomato, uniformly smooth and solid. Color, a deep, rich, bright red. Plant a vigorous grower, but better suited for open air culture than for forcing.

Maule's Imperial.—Large in size, perfectly smooth and solid, and if carefully fertilized would make an admirable forcing tomato. Color, a rich, glossy, purplish crimson. Well worth further trial, both under glass and outside.

Perfection.—One of the Livingston tomatoes, and not a new one. It is a rich, red tomato, smooth and solid, and of good size, but is too poor a setter of fruit for profit. We have found the same fault with it in the open air.

New Forcing.—This variety was sent for trial without name, by W. H. Maule, of Philadelphia. It makes very smooth and handsome fruit of a brilliant red color, and we will give it further trial. With us it has done as well as the Lorillard, under similar conditions.

Stone.—Fruit very smooth and solid. Color, bright red. Fairly good, smaller than the last one, but rather more fruitful. One of the best in open air culture, and worthy of further trial under glass.

White's Excelsior.—Fairly early for so large a tomato, but rather a poor setter under glass. Decidedly the most showy tomato of the whole lot, and may do better with careful hand setting. Color, purplish red. A superb fruit, and worth trying further.

Purple Advance.—An early, deep purple colored tomato, but entirely too small for profit under glass. Not worth growing in the house, but its earliness may give it some value out doors.

Fordhook Fancy.—This has the broad potato-leaf foliage, and the habit of the Dwarf Champion. The fruit is not very large, but is decidedly the most handsome in appearance of any grown. Color, a rich, glossly, purplish red. Too unproductive for profit anywhere, and only valuable as a fancy tomato in small gardens.

Maule's Earliest.—This is the earliest tomato we have ever tested. Fruit of large size and bright red in color. In its present condition it is unsuited to forcing, though by far the most productive of any, because of its irregular and uncouth shape. No tomato we have ever grown excels it in productiveness, at least no large one. If it can be bred into a uniformly smooth shape and retain its other good qualities, it will be an invaluable tomato for forcing or for open air culture. We intend to work with this variety with the hope of curing its one bad characteristic. Once bred into a smooth fruit, it would leave little to be desired in a tomato, as its color is of the brightest and its flesh solid and fine. It seems to us to be the starting point for a tomato of remarkable value for the market. Some of our plants made uniformly smooth fruit, but the majority were very irregular. We propose to remove some of the smoothest plants from surrounding influences by propagation from cuttings and from these to select seed, hoping finally to establish a heredity of smoothness by careful selection. It is the most profuse bloomer of any tomato tried, and if the whole product had been carefully hand pollenized, the crop would have been much larger. There is, in our opinion, more of promise to the trucker in this tomato than in any under test, and we believe it can yet be made the forcing variety of all others.

POLLENATION.

An inspection of the figures given will reveal the fact that after the 26th of January, there was a general falling off in the product. This was not caused by any decrease of vigor in the plants, but simply by the lack of perfect pollenation. All the fruit that ripened up to the 26th of January had been carefully fertilized by hand with a camel hair brush. Most writers on the subject of tomato forcing

advise the shaking off of pollen in a spoon, and then applying it to the pistil. Whether anyone ever did this I can not say. Certainly we did not succeed in doing anything of the sort. But we did succeed in pollenizing perfectly by wiping off the pollen with a camel hair brush, and applying the brush, bloom by bloom, to the pistils. Other writers have said that it is sufficiently to daily jar the blooms by tapping them about noon daily. With a view to test the difference we, after the first few fertilizations with the brush, had the blossoms jarred daily. The result was an imperfect setting of the fruit and a rapid falling off in size, and hence a reduced crop from what it would have been had the careful hand fertilization with the brush been continued. There may be conditions under which the pollen will shake off, but we never found it in any such condition. With us the camel hair brush is the only reliable pollenizing implement.

Of course under the conditions of this test no conclusions can be drawn as to the profit in a commercial way of forcing tomatoes. We hope another season to make a complete test with a good forcing variety, and the most careful hand pollenation. The crop tabulated does not include all the tomatoes grown in the house, since there were a considerable number of plants fruited besides those in the variety test. The tomatoes which were sold brought 25 cents per pound, which is a fairly good price as compared with the market quotations in the Northern cities at wholesale. All that were sold, were sold in Raleigh and at the winter resorts in North Carolina, and many more could have been sold.

With a narrow, lean-to house, built especially for this purpose, we are of the opinion that the crop of winter tomatoes can be made a very profitable one here with the great increase in the patronage of our winter resort hotels in the sand-hill country.

The abounding sunshine which we usually have, even in the coldest weather, is a great advantage in winter forcing in this climate, and renders it possible to get better results at a lower cost than can be had in the North, with their long dark spells in winter, and their heavy snows, to say nothing of the greater amount of coal that is required by reason of the more severe climate.

Winter gardening is in its infancy in the upper South. Our

people have found that with the slight protection of cloth, they can grow very profitable crops of lettuce. With glass they can grow far better crops of this, and have the crop more secure. When once the gardener gets to using glass on simple frames, it is but a step to the more intensive work of forcing in heated structures. The competition of the South compelled the Northern gardeners to intensify under glass, until acres of land are now covered with forcing houses around all the great Northern cities. The competition of the tropics will soon compel the gardeners of the upper South to adopt to some extent the methods that have brought profit to the Northern gardeners. Therefore, as a contribution towards aiding in the work of using glass in gardening for the market, I have added a brief treatise on the use of glass, which I trust may be of value to those who realize the value of concentration of effort instead of the extensive methods that are generally used in the South.

It is proper to add here that all the work of the tomato experiment has been under the direction of my assistant, Mr. Alexander Rhodes, with the help of the following members of the Senior class in this department: Messrs. Bernhardt, Harrell, Hanff, Jones and Shore.

The Use of Glass in Market Gardening in North Carolina.

By. W. F. Massey.

INTRODUCTION.

The great development of market gardening in vegetables in the South Atlantic coast plain, and particularly in the part of North Carolina where the conditions of soil and climate, and the facilities for transportation of the products by rail and water, are so favorable, calls for greater skill on the part of the growers, and more intensive culture. Our people in all lines of soil culture are too much inclined to spread out over large surfaces, and to try to do things on a large scale. This tendency is an inheritance from the old cotton-planting days, and it is hard for Southern men to realize what may be done by intensive culture on a small area. Our market growers have mainly confined their attention to those crops like the early potato and cabbage and peas, which bring returns at once, and which require little special skill on the part of the grower. The result has been that at times the product of these things is so great that no one gets fair returns from his investment and labor. Years ago when the development of trucking in the South seemed to the gardeners near the large Northern cities to threaten the destruction of their business, they were compelled to turn their attention to a more intensive way of gardening, and to use glass in a skillful manner to produce crops of high quality out of the regular season. In this they have succeeded to such an extent that market gardening under glass has become an established industry near all the great cities of the North, and the profits from such intensive culture are far greater than any made in the open ground anywhere. Thus the Northern gardeners have been enabled to compete with the products from the far South and the tropics, by reason of the superior quality of the products thus grown, and their better condition when offered for sale. To such an extent has this culture under glass grown in the North that men

are now growing under glass, in the semi-arctic climate of Vermont, winter cucumbers and other vegetables for the New York and Boston markets, at points as distant from market as North Carolina, and under conditions far more expensive and difficult than any here. The Northern gardener under glass is compelled in many places to use double glazed sashes on his houses to exclude the cold, and far more expensive heating arrangements, and a great deal more of coal than would be needed in heated structures here. Our abounding sunshine, even in the coldest winter weather, and the absence of the long sunless spells with which the New England gardeners have to contend, would give us a vast advantage in greenhouse culture in winter. Then, too, the fact that crops like lettuce, which they grow in heated houses, can be produced here in simple frames and loose glass sashes in as great perfection as they grow the same in heated houses, gives us an advantage that we should not be slow in adopting.

With our growers, as soon as they begin to consider the matter of winter gardening, the first thing is to get something which they imagine is cheaper than glass. Our gardeners seem to think glass an exceedingly costly article. Hence, when they propose to grow lettuce, they make great wide beds and cover them with cloth, which is commonly kept on too constantly, thus really retarding the plants, and in these wide and high frames with the cloth cover, it is almost out of the question in severe spells to prevent serious damage from frost, which would not be the case in narrow, low, glass-covered frames. Instead of being cheaper, the cloth is, in the long run, far more expensive than glass, and when the difference between the crops is considered, it is the most costly from the start, because of the less profit that can be had from it. When snow falls, the cloth-covered frame is usually in a bad way, but on a glass-covered frame the snow is a protection from the cold wave that usually follows the snow fall. Then, too, with the glass we can grow more than one crop during the winter, and can use it for other crops besides lettuce, such as beets and radishes, and for the forwarding of the plants of tomatoes, egg plants and other things. When once the gardener gets skillful in the handling of simple sashes on a cold frame, the transition becomes easy to the greenhouse, and the heated hothouse for more tender

things. It is for the purpose of encouraging our people to acquire the necessary skill in gardening under glass that this bulletin is prepared. Products that require for their perfection the outlay of capital, and which are in the nature of a permanent investment, are always more certainly profitable than the crops that anyone can grow in the open ground, and which are, therefore, constantly liable to meet a glutted market. In the production of winter crops, as I have suggested, our growers have a decided advantage over those further North, and the margin between cost and the selling price will always be larger here, and will more than balance the cost of transportation. Just as the Southern cotton mills are successfully competing under more favorable conditions with those in the North, so our gardeners under glass, with our bright sun, can grow crops more cheaply and better than those in the dark winters of the North.

But the gardening under glass, requires more careful study and greater watchfulness than gardening in the open air, and it behooves us to gain by experience before branching out on too large a scale. When once a man who is in love with his calling, begins to grow better products than his neighbors he soon reaps his reward in better prices. The lettuce, for instance, which is grown under plant cloth, goes to market usually in barrels, and is sold as "Southern field lettuce," by the barrel. Lettuce grown well under glass and shipped in handy boxes is sold by the dozen at a higher price, and competes with the Northern greenhouse lettuce. The gardener with glass gets his lettuce into market at the Christmas holidays, and is ready at once to replant for a crop to compete on more favorable terms with the crop of the man who is using cloth, and as the spring crop usually sells for more than the mid-winter crop, his lettuce being in better condition, brings more money. I have gotten three times the price for lettuce the first of April that I got during the winter months, though the first paid very well. The many uses to which glass sashes can be applied is another argument for their use. After the lettuce crop is shipped the tomato plants are hardened off in the frames, and as after the first of March in this climate the lettuce does not need the glass, an extra set of frames can at once be used for the tomato plants that have been started in hotbed or greenhouse.

And after the tomato plants are removed to the field the very tender egg plant can be set in the frames, and protected during chilly nights, and thus brought on at a time when it will command a good price. Or a hill of cucumbers can be planted under each sash from plants started in pots in the greenhouse and brought on earlier than those in the open ground far south of us. Then after all the plants have used the glass, there is no better place for the drying of fruit in summer than under these same sashes. Those whose interest is in the strawberry crop, can use the sashes to cover strawberry plants set for this purpose in frames, and if the sashes are put over them the first of March or a little earlier the crop is rapidly advanced, and the blooms protected from frost, so that the fruit goes to market far ahead of the open-air crop.

Therefore, if you intend to adopt intensive gardening, and strive for the production of crops in winter, we would urge that you drop at once and forever the idea that plant cloth is cheaper or better than glass, for it is neither.

COLD FRAMES.

The name cold frame is applied to a simple frame set on rich soil, and covered with glass sashes. This name is to distinguish it from the hotbed in which a pit is dug under the frame and filled two feet deep with fermenting manure to heat the frame above. The hotbed soon becomes a cold frame as the heat of the manure dies out. Hotbeds are little used now-a-days by gardeners, because they are in the long run far more expensive than heated greenhouses, and far more laborious and troublesome to manage. The sashes for the cold frames should be of the regular size, three feet wide and six feet long. It has been found by long experience that this size is the most easily handled, and makes a bed more easily worked than larger or longer sashes. The sash being then six feet long, the frame to receive it will be nearly that width, and can be made as long as one chooses. The rows of frames in a framing ground should be far enough apart for a cart to go easily between each row. This will give room to pull off the sashes entirely on occasion, and room to get around with manure, etc. The frames are constructed of one and a quarter or one and a half-inch stuff, and should be 16 inches high at the back

or north side, and 12 inches on the south side, and should, of course, run east and west, with the slight slope of the glass to the south. Between each sash let into the sides with a dovetail on each end a three-inch strip of stuff, but do not nail it fast. Simply let it hold the sides together by the dovetails. On this strip nail an inch parting strip to form a slide for the sashes which rest on the first strip, which is flush with the top of the frame. Some gardeners have dispensed with the cross-bars entirely, and fasten the sides of the frame firmly to posts, simply setting the sashes across from side to side. They claim that this is an advantage besides saving lumber, as the whole frame is clear, and they can use a horse in preparing the ground. But it will always take two hands to handle the sashes in this way, while with the slide one man can attend to the airing, and can give little or more as needed, and the cross-bars, being simply dovetailed, are easily knocked out while the ground is being prepared. We much prefer to use the cross-bars, and a further advantage is that the crack between the sashes is closed to the cold.

Sashes for frames should be made with a groove on the bars just deep enough to allow the glass to slide in end to end. This is a great saving as no puttying is needed, but care must be taken to fit the glass up close, and to drive a tack at the lower end to prevent the glass from sliding down. With glass put in in this way, if one is broken there is little trouble to slide the others up and put in a piece at the bottom, and the sashes are lighter and more easily handled than when puttied.

THE USES OF COLD FRAMES.

We have already in the introductory chapter told of some of the uses of cold frames. The main crop for which they will be used here is the lettuce crop. Lettuce needs a rich soil, but prefers quite a sandy one, and if the natural soil where the frames are located is not sandy it will be far better to excavate the whole to the depth of a foot, and replace the natural soil with a compost made by piling sods, manure and sand during the previous summer and turning the mass frequently so as to get it well rotted and homogeneous. If the soil is naturally sandy this will not be necessary. The frames should be gotten ready early in the spring, and the fertilizer needed by the

lettuce should be placed in the soil months ahead of the planting of the crop, for otherwise the commercial fertilizers are apt to burn the roots of the plants. A crop of radishes can be taken from the frames to pay for the work the first spring, and to get the soil ready for the fall planting of lettuce. If stable manure is to be used in the frames it should be well rotted and placed in the frames early in summer, and the soil should not be allowed to get weedy, but can be used for the production of cucumbers during the summer. Then in the fall a light dressing of cotton-seed meal will be all that is needed, and this should be well worked into the soil.

SOWING LETTUCE SEED.

The seed for the Christmas crop of lettuce should be sown the last of August or first of September, in a bed well enriched and prepared for the purpose. For this crop we use the Boston Market or Tennis Ball, a small-headed and compact growing sort, which can be planted more closely in the frames than the Big Boston, which does better for the second crop. In building cold frames always build twice as many as you have sashes, for in no other way can you use the glass so economically. The plants from the sowing of Boston Market the first of September, or the last of August, if the weather is better, will be ready to set in the frames in October or earlier. At the same time we sow the lettuce, we sow a bed with Snow Ball Cauliflower. These we set in October, six plants to each six-foot sash, and then fill in between them with lettuce, so that we have 40 plants of lettuce and 6 cauliflower plants, the cauliflower plants being set in two rows 18 inches from each other and 18 inches from the sides of the frame. As fast as the plants are set the bed is watered and the sashes placed over and shaded by throwing a little sand over the glass. As soon as the plants take hold of the soil the glass is removed and cleaned, and is not put on again till the nights are frosty, and during all sunny weather the glass is slipped down more or less so that the lettuce does not grow too soft and flabby, which will make it ship badly. By the time the lettuce is cut out, the cauliflower plants will be getting large, and should be gradually tempered to the outer air so that when the other frames are planted with lettuce the sashes can be taken off and the cauliflower left to complete its growth without glass, which will bring its heading time the last of March or first of April.

SECOND CROP OF LETTUCE.

The seed for the second crop should be that of the Big Boston or the Cal. Butter. The seed should be sown the latter part of September or early in October in a bed well sheltered from the cold winds, and as the cold increases the bed should have a light cover of rough manure, but not to hide the plants. This will be sufficient protection till they are needed in January or February. These varieties grow much larger than the Boston Market, and should have 12 inches of space for their full development. The same care is needed in the transplanting as with the fall planted crop, but the sashes will have to be kept on more continuously for a while. But in all cold-frame management remember that the bright sun, even in quite cold weather, raises the temperature in the frames, and there will always be need of a little air during sunshine in the coldest days. If snow falls let it lie, for the snow is almost always followed by a cold wave, and there is no better protection for the frames than a coat of snow on the glass. This second crop will come on in March, and as the lettuce will hardly need the glass after the first of March, it will be very convenient to have still other frames ready for tomato plants that should have been sown in January, and transplanted in the greenhouse, and are now ready for "spotting out" at intervals of four inches in the frames to get gradually hardened to the open air, and be ready for setting in the field the last of March or first of April. By giving the tomato plants plenty of room, and all the air admissible on sunny days, and finally full exposure at night, they will get tough enough to stand a little white frost, and the earlier the plants can be gotten out and survive, the earlier the crop will be. I have had tomatoes stand quite a frost unhurt, after careful hardening off in the frames.

If the tomatoes are out of the frames the first to middle of April, you should have a nice lot of egg plants or cucumbers in four-inch flower pots ready to take their places under the glass. If egg plants, then plant two to each sash, and if cucumber but one hill to a sash. Give air as needed in warm weather, and carefully cover in chilly weather and at nights, so long as it remains cool, finally giving full exposure when the soil all around remains warm at night. To keep

the sashes and frames at work in this way the gardener must have some glass in hotbeds or a fire-heated greenhouse. The greenhouse is far the best and most convenient. If a hotbed is used the frame is constructed as for the cold frame, and is placed over an excavation not less than two feet deep. This excavation is to be filled with fermenting manure prepared as we will describe, and covered with four inches of fine, rich soil, in which seeds are sown or plants transplanted. To prepare the manure for the hotbed you will need fresh horse or mule-stable manure, well mixed with straw or leaves. Oak leaves will be better than pine, as they hold the heat better. Pile the manure, and as soon as it begins to steam, turn it over and throw the outside to the inner part of the heap. When it heats again turn again. Turn about three times before using, and then pack it tightly in the excavation, tramping it evenly all over. Then, after the pit is full, place the soil over it, and set a thermometer in the soil, and put the sash on. Watch till the heat begins to decline from the first rank heat, and the mercury stands below 90, and you can sow the seeds of tomatoes. Have the bed ready in late January for this purpose. We prefer to sow the seed in shallow boxes, and set in the hotbed, a small box being sufficient to start plants for a large bed, and for a much larger cold frame in the second transplanting. A hotbed of but two sashes will start plants enough to take hundreds of sashes at the second transplanting. When the plants in the box are large enough to handle, transplant them in the bed, two inches apart, and then give all the air the weather will allow so that the plants do not grow too fast and tall. Should they be inclined to run up, then top them to make them stout. By careful attention to air the plants should be able to endure the cold frames by the first of March, and should be placed there about four inches apart each way, and gradually hardened off as we have said.

HOW TO BUILD A CHEAP GREENHOUSE.

For the gardener who only wishes to grow the crops we have named, and who does not intend to go into winter forcing under glass, but a small greenhouse will be needed. The house is to be used simply for the starting of plants to be afterwards used in the frames, and to take the place of the uncertain and laborious hotbed. Such a

house can be easily built by anyone who can handle a saw and hatchet. The best and cheapest plan is that first recommended by the late Peter Henderson, in his book on Gardening for Profit, a book that should be read by all market gardeners.

It is built by using the ordinary sashes 3 x 6 feet that are used on cold frames and hotbeds. The walls of the house are made by setting good, stout posts in the ground in parallel rows ten feet apart, and cutting them off at the height of four feet to receive a plate on which a gutter is constructed. The sashes are then attached in alternate pairs to the ridge pole, which is shaped to receive them. These alternate pairs of sashes are screwed fast to the ridge pole and the gutter to form the rafters to support the ridge. Alternating with these are pairs of sashes that are hinged to the gutter and loose at the top, where they are fastened down by an iron strap punched with holes to set on an iron pin in the ridge, so that they can be lifted and fastened open for ventilation. Benches are constructed on the inside, at a height of 18 inches below the glass at the eaves, on which soil can be placed or sand for pots to sit upon. This leaves a walk two and a half feet through the centre of the house. The house should run north and south, and at the north end it is extended into a shed in which the heating apparatus is placed. If the house is to be heated with a furnace and smoke flue it should not be longer than 50 feet, but if hot water is used the length may be doubled or more according to the capacity of the boiler. Heating with a flue is the cheapest method for a small house, but far the least satisfactory, as there will always be a difference in temperature between the two ends of the house, that near the furnace being the hottest. There is also trouble at times from the escape of gases from the most carefully made flue, so that, where the first expense can be accomplished, it is always best to use hot water, and to put in a boiler of such a size that future additions may be made from time to time, and the necessity for more room occurs, without increasing the boiler. It is far cheaper to heat a house with a boiler of greater capacity than is actually needed, so that there is never any necessity for hard firing. If the heating is done by a furnace and flue there must be an excavation made in the north end of the building deep enough to accommodate the furnace and ash pit, and to bring the crown of the furnace arch just below

the level of the floor of the house. The furnace should have a good-sized ash pit, and in inside area should be 18 inches wide by 30 inches deep so as to give a good grate surface. From the top of the rear end of the arch a flue should be constructed of brick in a nine-inch wall rising to the level of the floor, and then gradually rising for a distance of 15 feet from the furnace. From this point terra cotta tile six inches in diameter can be substituted for the brick, and the flue carried around the entire house on a gradual rise till it returns to the chimney on the opposite side of the north end from the furnace. At this point, the old practice was to make the chimney of four boards nailed together and set on end. But this is a dangerous practice, for in times of high winds and a strong draft, the fire may get around the hundred feet of flue and set fire to the building. Hence it is better to terminate the flue in brickwork and top off with an ordinary terra cotta pipe. A good cast-iron door and frame are needed for the furnace, and the entire front can be bought from those who deal in greenhouse structure. Hard coal should be used in the furnace, so that a slow fire can be maintained during the night without constant attention, and the furnace should be of sufficient capacity to allow of a good mass of coal. If wood is used, the furnace should be at least four feet deep, and the ash pit and grate will not be needed, the draft being regulated by an opening in the door. The flue in this case should be made of brick the entire length of the house as the blast from wood will be too much for the tile. A wood-burning furnace may be made perfectly effective, if of sufficient size to admit large logs that will burn slowly all night without attention, but will be far less effective and satisfactory than hard coal.

A novice in greenhouse work usually keeps too much heat on and pays too little attention to the ventilation in the hours of bright sunshine. A night temperature of 50 degrees is warm enough for most of the plants needed to be started early for the market garden, and in a flue-heated house the warm end, where there will be a temperature of 60 to 65 degrees will be the place for egg plants and other tender things. A little practice will soon enable a man of intelligence to manage plants under glass successfully, and he will find that a small fire-heated greenhouse is far better, and in the long run, cheaper, than the manure-heated hotbed.

Such a house can also be used for the winter-forcing of tomatoes, cucumbers and snap beans. For forcing tomatoes, the benches should be covered with a good rich soil, and drainage made by having the benches made in slats and cover them with sods before filling in the compost to prevent the earth sifting through. The plants should be grown from seed sown the last of August in the open air, and transplanted once before setting them in the house. They can be planted 15 inches apart along the sides of the house, and trained to single stems on wires a foot from the glass. Cucumbers are grown in a similar way, but need a higher temperature than the tomatoes. A crop of snap beans can be taken along the front of the bench before the tomatoes need all the room. The best variety for this purpose is an English sort called the Pride of the Market. It is of very quick growth and productive. We have grown them with great success with two plants each in a six-inch flower pot. For forcing tomatoes, a night temperature of 60 degrees is best, while cucumbers do better with a night heat of 70 degrees or over. The short American cucumbers should have their flowers pollenized by hand, but the long English cucumbers will grow to full size without pollenizing.

Forcing vegetables and fruits in winter successfully requires the highest skill of the gardener, and the novice had better go slow until he learns by experience, or had better work at the business a while under skillful instruction.

The following Bulletins have been heretofore issued by the Division of Horticulture and Botany, which are still available:

No. 112. Trucking in the South, pp. 70.

No. 129. Horticultural Experiments at Southern Pines, 1895, pp. 46.

No. 138. The San Jose Scale in North Carolina, pp. 14.

No. 147. A Study of Lettuces, pp. 8.

No. 149. The Apple in North Carolina, pp. 36.

No. 159. Horticultural Experiments at Southern Pines, in 1896, pp. 92.

No. 162. Farming in North Carolina, pp. 34.

No. 164. The Flora of North Carolina, pp. 80.

Others have been published, but are now out of print. Any of the above can be obtained on application to Dr. George T. Winston, Director of the North Carolina College of Agriculture and Mechanic Arts, Agricultural Experiment Station, West Raleigh, N. C.

BULLETIN NO. 171 MAY, 1900

THE NORTH CAROLINA

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

AGRICULTURAL EXPERIMENT STATION DEPARTMENT.

GEO. T. WINSTON, A.M., LL.D, DIRECTOR

Corn Culture in North Carolina

1st. Kinds of Land Suited for Corn Culture.
2d. Preparation of the Soil.
3d. Planting, When and How.
4th. Fertilizers to be Used on Corn.
5th. How to Cultivate, and Why.
6th. A Good Rotation for Corn.
7th. Varieties Best Adapted to the South.
8th. Harvesting the Crop.
9th. Selection and Improvement of Seeds.
10th. Protection Against Weevils and Moths.
11th. Comparative Food Value of Corn and Other Crops.

B. IRBY, AGRICULTURIST.

WEST RALEIGH, N. C.

Publications will be sent to any address in North Carolina upon application.

THE NORTH CAROLINA COLLEGE OF AGRICULTURE AND MECHANIC ARTS

AGRICULTURAL EXPERIMENT STATION DEPARTMENT,

WEST RALEIGH, N. C.

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The Station is glad to receive any inquiries on agricultural subjects. *Address all communications to the Agricultural Experiment Station, and not to individuals.* They will be referred to the members of the Station staff most competent to answer them.

Corn Culture in North Carolina.

By B. Irby, Agriculturist.

KINDS OF LAND SUITED FOR CORN CULTURE.

Corn grows well on most any of our soils, but it reaches perfection on our black soils, on the lime, clay, clay loam and sandy loam. The rich alluvial bottom lands, which are composed of a general mixture of the different soils, would of course give the best possible yield.

The corn crop is a very heavy feeder, as indicated by the large number of surface roots. Hence the crop needs an abundance of rain. It draws heavily on the soil not only for plant food but moisture. In selecting a soil for a large yield this important point must not be overlooked.

Compared with others, this crop evaporates far beyond the average amount, and this large demand must be supplied. By careful experiments and estimates, it has been found that the evaporation is as follows, for this and two other crops:

Corn producing 50 bushels per acre requires 1,500,000 pounds of water.

Potatoes producing 200 bushels per acre require 1,268,000 pounds of water.

Oats producing 29 bushels per acre requires 1,192,000 pounds of water.

There are other crops that exceed the corn crop in evaporation of water, but the above amount is enormous. Taking this into consideration, the texture of the soil, and its power of holding moisture is of vast importance in selecting a soil for growing this valuable crop. A peaty soil, or one very rich in organic matter, when well drained, will make a very fine crop, not because it is so rich in plant food, but because there is usually no lack of water during the growing season.

The retentive power of different soils is illustrated by the following table.

Professor Schubler, of Tubingen, found that by taking 100 pounds of the different soils, and dropping water on them until the water began to drip from them, that:

The sand held ....25 pounds of water.
The loam soil held ....40 pounds of water.
The clay loam held ....50 pounds of water.
The pure clay held ....70 pounds of water.

From the above table it will readily appear which is the best soil for corn according to the amount of water supplied.

Of course the texture and fertility would also come into the consideration. But we see at a glance that it is best to select one that is naturally very deep, and rich in plant food, thus affording an extensive area in which the roots may feed.

The soil if deep, will not only furnish an abundance of plant food, but it will act as a reservoir for water, giving it off as capillary water between the rains, thus supplying the roots which naturally grow near the surface.

The texture or condition of the soil is ideal when the average rain in sinking down, as free, or drainage water, is absorbed by the porous soil, and then becomes capillary water and hygroscopic water, reserved for future use.

If the soil is shallow it will be impossible for it to hold much water, hence a heavy rain will run off on the surface, doing great damage. Thus it is that we may always expect best results from our rich bottom lands that are well drained.

This crop, though requiring such abundance of water for its growth, is easily "drowned out," and suffers severely when it stands in water. Hence the proper drainage of the soil is of prime importance. A soil may be very rich in plant food, and one year with a favorable season make fifty or seventy-five bushels of corn, the next year it may be "drowned out" and make absolutely nothing. If this land was properly drained it would not only make a good crop every year, but average a better crop than was made in the good years before the drainage was employed. Corn will turn yellow and soon die if the land is too wet; so, too much stress can not be laid on thorough drainage.

Lands that are too wet at one season will suffer from drought, and lands that usually suffer from drought need drainage, though the statement may seem paradoxical. Hence to drain a soil will enable it to store up water. The reason is obvious, as the water is all compelled to pass down through the soil and the surplus simply passes off in the drains, while the bulk of the rain remains caught up in the soil.

When well drained, the soil becomes more porous and open, or sponge like, and its capacity for holding moisture is thus increased. The free water passing down through the soil opens up innumerable

channels, and these will hold moisture, as capillary water, as soon as the extra pressure is off.

PREPARATION OF THE SOIL.

The best farmers do a great part of their work before the planting is done. This preparation varies, however, with the soil.

For example, heavy clay soils should be plowed deep in the winter, or in the fall, but sandy loams should be plowed deep only in the winter and early spring would be better. The clay soils need the disintegrating effect of the freezes and thaws. They have a tendency to become too compact, whereas the sandy soil is much more open and porous and becomes too loose. Hence very light sandy soils are not much benefitted by this early plowing and freezing. The lime soils are greatly benefitted by deep plowing and by the action of winter weather. In a general way it can be said that the clay and lime soils are heavy, and should be treated very much alike. Heavy soils should never be plowed when wet, as they bake, and the bad effect does not disappear for years.

If the soil has not been plowed deep previously, then it would be best to deepen the soil gradually, say by going one inch deeper each year until the desired depth is reached. Many make shipwreck of a good thing by plowing too deep the first year; it is not always best to completely upset the soil. Plows are constructed to turn the soil but half over, thus leaving the land or strips edged up, affording free access for the air and catching all the water that may fall on the land. It can be readily seen that this would be the ideal condition where the clods, or flakes freeze, as they get soaked with water and the freezing bursts them to pieces, and when they thaw they are as mellow as an ash bank. Where the soil is shallow and the subsoil a stiff clay, it would be best to use a subsoil plow, following the turn plow. The idea is of course to loosen the subsoil, without bringing it to the surface. This deepens the seed bed, and also increases the storage room for water, and allows the roots to feed deeper.

The light soils are benefitted by an occasional deep plowing, but generally speaking they are too loose already, and should rather be made more compact. Hence on the light soils it is better to break just before planting. In this way one plowing can be saved and a better stand of corn obtained. The texture of these light or sandy soils can be improved by plowing to the same depth year after year, and using a heavy roller to compact them, thus increasing their moisture holding capacity.

PLANTING, WHEN AND HOW.

There are three methods of planting. On the ridge, on the level, and in the furrow. The soil, time of year, and weather, will determine which is the best. In some sections it would be well to plant very early, or very late to escape the ravages of the bud worm that infest the corn in May and June.

Very early in the season, when extra early corn is needed, as for roasting ears, the bedding system would be advisable, and the corn should be planted shallow. If the land is wet and cold, then the bedding system is the only safe way to plant.

If the land is well drained, and the soil deep, and the season has fully opened for planting, then the level system should be used, and seeds planted about two inches deep.

Late in the season, especially in sandy soils, it is best to use the furrow system and plant deep, so an abundance of moisture is insured, and the germination is much more certain.

If the soil is stiff clay, break in the fall or winter, and then in the spring run over this land that has been freezing and thawing for the last two or three months, with a spring-toothed harrow, or cutaway-harrow, and if it is not smooth and level, the smoothing harrow should be used. This leaves the land in perfect condition for the corn planter, which should always be used. If the farm is large and has enough land to justify, a two-horse planter can be used; but ordinarily, a one-horse planter will answer. It is best to use one that drops the seed immediately under the opener and has a heavy wheel from four to six inches wide to follow, which not only covers the corn, but packs the soil around the seed, causing it to germinate more perfectly. On large level tracts a two-horse planter and check rower can be used to advantage as it saves hand labor. The advantages of the planter are as follows:

1. The planter will do better work than can be done by hand, and will save seed.

2. Corn will come up quicker and more uniformly as to time, when a planter is used.

3. It will be easier to work, or cultivate, and the use of two men and one horse will be done away with, that was necessary when planted by hand. It will pay to buy a planter if the farmer has but ten acres in corn.

4. It is not necessary to lay off the rows if a planter is used, as any good plowman can be guided by the last row planted.

The distance between the rows, and the distance between the hills on the rows will be governed by the fertility of the soil and by the variety of corn planted.

In thin land the rows should be far apart and only one or two stalks to the hill, and these hills at least three feet apart.

With rich land the rows should be four feet apart to give plenty of air, and for convenience of working; but the corn should be thick on the row, say two stalks in the hill, and not over two feet apart from hill to hill. If for ensilage or stover, then it might be planted still thicker in the row.

If the corn is planted as above directed, it is easily possible to make seventy-five to one hundred bushels per acre. Of course, after all, each farmer must use his own judgment in these little practical questions that come up. Many make the mistake of planting too far apart, and the land does not produce as much as it could. Others of course leave it too thick and find it "burned up," and poorly eared at the end of the season.

If the rows are four feet apart and one stalk in the drill four feet apart, then it is impossible to have more than 2,756 stalks, and if each stalk average one ear, the yield will be about twenty-seven bushels per acre. Possibly this amount would be the capacity of the soil, but it is often the case that it might support many more stalks and of course make a much larger yield.

In using a planter about one gallon of seed corn will be necessary for one acre. This gives plenty and to spare for ravages of birds and insects. The idea should be to put in more than enough, as it is far better to thin out than it is to replant, certainly less trouble, and the replants never amount to very much any way.

If properly managed, the corn does not need any hoe work, but it is of course best for the extra stalks to be cut out, and the skips to be replanted.

FERTILIZERS TO BE USED ON CORN.

Just what fertilizers to use, and which will be most economical, is a perplexing question to farmers each recurring year.

We have to apply potash, nitrogen and phosphoric acid, if they are not already in the soil in sufficient quantities, which is indeed seldom the case.

The nitrogen usually costs about three times as much as either of the other ingredients, but fortunately the nitrogen-gathering plants may be depended upon to store up in the soil this valuable element for the succeeding crop.

By adopting a rotation in which clover, peas, soja beans, or similar plants, take a prominent place the fertility of the soil may be gradually increased, and at the same time much valuable food will be made for the farm animals.

Thus he may reduce his fertilizer bill to a minimum, for he then has nothing to buy but phosphoric acid and potash.

Many times this leguminous crop has not been planted, and the complete fertilizer has to be supplied. The farmer can either buy this ready mixed, or buy his own ingredients and do the mixing. Under good fertilizer laws he is now certain of getting what he has represented to him, and if he does not, then he can recover damages. If he deals with responsible agents there need be no doubt in his mind as to what he is getting. But he can be sure of one thing, and that is, that he will pay more for the same amount of available elements in the complete fertilizer from the factories than when he buys the ingredients, and does his own mixing. In other words the factories will not mix, sack, and brand fertilizers for nothing. They must be paid as middle men, as well as for the expenses incurred. For example, the farmer in many parts of the South can now buy cotton-seed meal, tankage, nitrate of soda, refuse from the gas factories for his nitrogen, bones and acid phosphate for his phosphorus. And he can buy kainit, muriate of potash, ashes, etc., to supply the potash needed. The only question now is just how to mix them, and how much per acre to give the same result that the ready-mixed gives.

If the fertilizer bulletins are examined it will be found that the different brands average about 2 1-2 per cent ammonia, 8 per cent phosphoric acid, and 2 to 3 per cent potash. Of course when a fertilizer is mixed some formula should be adopted, and the ingredients so mixed that they will produce the desired per cent of the three valuable elements.

To make a fertilizer equal to or better than the above formula he can use the following:

	Ammonia.	Phos. Acid.	Potash.
Cotton-seed meal containing	8.5 per cent.	2.5 per cent.	1.8 per cent.
Acid Phosphate containing		14. per cent.	
Sulphate of Potash containing			50 per cent.

Tabulating these and making up a mixture he has:

		Ammonia.	Available Phos. Acid.	Potash.
Cotton seed meal	900 lbs.	76.5 lbs.	22.5 lbs.	16.2 lbs.
Acid Phosphate	1,000 lbs.		140.0 lbs.	
Sulphate of Potash	100 lbs.			50. lbs.
	2,000 lbs.	76.5 lbs.	162.5 lbs.	66.2 lbs.
Per cent contained		3.8	81.1	3.3

This will be a better fertilizer than the average ready-mixed, because it has a higher per cent of all the ingredients, and as a gen-

eral thing will cost from two to five dollars less, the mixing and resacking will not cost over 25 cents per ton.

Spread the phosphoric acid on the barn floor, say six inches deep, then put on the meal, then the potash. Start on the edge, and cut through the pile with a hoe, pull it out slightly each time. When the center is reached, then take a shovel and throw it back to the center, being careful to let it fall each time on the top of the pile, and roll down on all sides. Repeat this operation four or five times, and the pile will be found to be well mixed. This can be discerned by the blending of the colors of the fertilizers. Now set a small screen up and open the sack under it on the scales. Throw the fertilizer in the screen, and as it goes in the sack it is cleaned of lumps, strings and trash and is weighed. Write the weight on each sack and it will save re-weighing when carried to the field. This fertilizer can be stored away in the barn, and will be in good condition six months from the day it was put there. This is not so with the ready-mixed fertilizers. They get hard and caked, and have to be mashed up before using. Then again, you can vary the fertilizer mixture to suit the crop and the land.. If one piece of corn is on land that was in clover the year previous, not so much nitrogen is required. If the land has been in an exhaustive crop for two or three years, more nitrogen will be needed. If a farmer once gets into the habit of mixing his own fertilizers he will continue to do so unless the relative prices change wonderfully.

Within the last few years the factory mixed fertilizers have gone down in price, while at the same time the market price of the different ingredients have increased. This indicates that the home mixtures are becoming more popular with the users of commercial fertilizers. It is best to apply the fertilizer at two different periods, say two-thirds in the drill just before planting, and one-third in the middle just as the last plowing is done.

Now that the fertilizer is applied, and the corn planted, the next thing is the cultivation.

HOW TO CULTIVATE, AND WHY.

If the land is inclined to be crusty, or to bake, it would be well to run over the crop with a smoothing harrow just before the corn comes up. Run the smoothing harrow right across the rows as if it were the intention to tear the corn out of the ground; remarkably few hills will be disturbed, however. A few days after this harrowing, run around the corn with a five-hoe single-horse cultivator, going as close to the corn as possible without disturbing the roots, or covering up the corn. The plant by this time is about six inches high, and

now it is ready for the hoe hand. He can cut out the surplus stalks, and when necessary replant, and uncover some that the plowman overlooked.

If in stiff land plow next with a double shovel, running five or six inches deep and about six inches from the corn. Let this be the last deep plowing. After this, use the single-horse cultivator, with three-inch hoes instead of inch and a half. Run only about two inches deep, or less, from now on; as the object is to break the crust and furnish a "dust blanket" or earth mulch to hold the moisture in the soil by retarding evaporation. This cultivation will destroy weeds and grass and aid chemical action, as well as retain moisture.

It is much easier to kill the fine weeds and grass as they germinate, rather than let them grow and depend on wrapping them up. These plowings with the cultivator should take place once a week, unless too wet to do good work.

Avoid running too deep, as the roots will be seriously injured, and root pruning is not good for corn.

Cultivate as long as the horse can get about in the crop conveniently, even up to the time of tasseling if necessary. If the crop is planted on a level, it should be cultivated on a level, as it will resist drouth very much better.

Except where lands are wet and subject to overflow it is best to plant on a level. This system will also help in the use of a corn harvester if the crop is to be cut for ensilage or stover.

If the land is cold and wet the corn must then be on ridges or beds, and must be cultivated that way.

On ordinary soils, with level cultivation the moisture will be retained in dry weather much better, and the roots will not be so much damaged by cultivation.

If ridges are to be used let the land be in beds eight to twelve feet wide, and the corn planted in rows four feet apart on these beds or lands.

A GOOD ROTATION FOR CORN.

It is far better for the crop and much more economical if the corn is grown in a rotation. Where clover can be grown, a five-year rotation can be made that will give the land the opportunity to recuperate and build up in the best way possible. This can be altered if clover does not thrive in any particular section, and something else put in the place.

A Good Five Year Rotation 100-Acre Farm.

1900 Corn and peas. 1901 Cotton. 1902 Oats or wheat and peas to follow. 1903 First year clover. 1904 Second year clover.	1900 Second year clover. 1901 Corn and peas. 1902 Cotton. 1903 Oats or wheat and peas to follow. 1904 First year clover.	1900 First year clover. 1901 Second year clover. 1902 Corn and peas. 1903 Cotton. 1904 Oats or wheat, followed by peas.	1900 Cotton. 1901 Oats or wheat followed by peas. 1902 First year clover. 1903 Second year clover. 1904 Corn and peas.	1900 Oats or wheat followed by peas. 1901 First year clover. 1902 Second year clover. 1903 Corn and peas. 1904 Cotton.

In the above diagram it will be seen that clover is recommended for two years, this is the biennial or red clover, it could be replaced with crimson, or German clover, and the rotation shortened up two years, besides requiring but three fields instead of five. If the crimson clover is substituted for red clover, then the clover should be sowed in September in the cotton, and the corn and peas should come next as the corn should follow the clover, the corn could be followed by oats or wheat, and if they are followed by the peas, six different crops will have grown on the land in three years, three renovating crops, two exhaustive, and one that is hardly an exhaustive, but a clean culture crop. It would run thus: Cotton from April to September, then clover in the cotton, clover until next May, then corn and peas, then in October put in wheat or oats, next June peas. Next spring the rotation would start over again.

Hairy vetch would be a fine substitute for the clover as it grows in the winter and there is very little doubt about getting a stand. If allowed to mature it will reseed itself. It is an annual and can be easily gotten rid of if desired. It is quite equal to the crimson clover as a nitrogen gatherer.

Peas can be sowed broadcast in the row, or drilled when the corn is laid by; the latter method is better. These peas will furnish all the seed needed for the next year and the vines will renovate the land.

If none of the clovers do well, then arrange the rotation thus: corn and peas first year; oats or wheat, second year, followed by peas broadcast; cotton or tobacco third year, and corn again fourth year, etc. All these rotations insure an abundance of organic matter in the soil, with just such diversity of the staple crops as the Southern farmer would usually grow. If this rotation is analyzed it will be seen that there are several features which should commend it to the progressive farmer.

Corn is found to grow best on a clover sod and will allow grazing of clover field up to time of preparation for corn, unless bud worms are liable to attack the corn, in that case the sod should be turned earlier.

Corn and peas can be followed by cotton very well, as the peas have restored and renovated the land. Corn is an exhaustive crop, but its bad effects on the land have been counter-balanced by the peas.

The cotton is considered an exhaustive crop, but it is not an exhaustive crop in itself, but being a clean cultured crop it brings about a condition of affairs that causes the land to become wasted by washing, as the land is kept clean, and the organic matter is necessarily burned out. Thus we have the clean cultured crop in between two grain crops.

The oats come next, and can be sowed in the spring if the cotton comes off too late. This crop should be followed by peas sowed broadcast. The next two years the land is shaded and prevented from washing, besides being renovated by the clover crop. The cost will be nothing for cultivation, and the crop is easily harvested, making handsome returns in tons of hay, to be used primarily as feed, but later for manure. The farmer may be sure that he will haul the bulk of his clover back in the form of manure.

The question naturally arises, how these fields will be manured. The oat crop sowed in the fall should have all that has accumulated, applied broadcast and turned under, or worked in with a cutaway harrow.

The cotton crop should have what accumulates between fall and spring in addition to some commercial fertilizer put in the drill.

The corn should also have a commercial fertilizer especially rich in phosphoric acid and potash, as it already has an abundance of nitrogenous matter in the clover sod of two years standing.

This potash and phosphoric acid should be about one to three, say 100 pounds potash to 300 pounds phosphoric acid, each containing 12 1-2 per cent available material.

What the crop needs at first is something to give rapid growth, then it can soon take hold of the coarser plant food stored in the soil, and get ahead of the weeds and grass.

By this rotation the corn can be grown at a low cost and only two fields will have to be commercially fertilized each year. Two will be manured, and four will be renovated, two with peas and two with clover.

Four fields are growing a crop that will find a home market, and only one a sale crop.

The four, oats, corn, peas and clover will be run through animals

at home, making refined products, and sold as meat, milk, butter, wool, etc.

The fertilizer bill will be only two-fifths of the usual amount. The farmer will keep a few hands and teams busy all the year, and not be rushed to death at one time and have nothing to do at another. The land will be renovated two years out of five and a great part of the time his stock can be pastured on some of the land.

It is not unreasonable to say that after the first five years he will make more cotton and corn with this rotation on 2-5 of the land, in addition to the other crops, than if he would devote the whole land to corn and cotton, year after year, according to the old method. It would not be unreasonable to claim that, with the renovation and extra manure, that the corn will make four times as much as is ordinarily made per acre.

The labor question is decidedly the most important that will have to be dealt with, and this rotation disposes of that matter pretty well. It is better to have four regular men well paid for the whole year, and hire a few through the year as needed, rather than a larger number of indifferent hands poorly paid, for only a few months, as is usually the case where just cotton and corn are grown.

VARIETIES BEST ADAPTED TO THE SOUTH.

Generally speaking the Dent varieties are the best for the South, but other varieties give good results.

Corn is now grown in the State for ensilage and stover, as well as for grain. Hence the need for a broader difference in the varieties is apparent. The corn can be grouped as follows:

For grain and stover the varieties best suited are:

The 100-Day Bristol, yellow.
Delaware County Dent, yellow.
Johnson and Stokes Giant Beauty, yellow.
Leaming, yellow.
Golden Beauty, yellow.
Chester County Mammoth, yellow.
White Cap Early Dent, yellow.
Early Mastodon, yellow.
Improved Golden Dent, yellow.
Oldham County Yellow, yellow.
Mortgage Lifter, white.
Hickory King, white.
Mammoth White Hite, white.
Riley's Favorite, white.
Cory's Klondike Corn, white.

Snow Flake, white.
Mosby's Prolific, white.
Red Cob, white.

For Grain and Ensilage.

Cock's Prolific, white.
Northern White Field, white.
Blunt's Prolific, white.
White Dent, white.
Red Cob Ensilage, white.
Southern Horse Tooth, white.

Many other varieties could be mentioned, but these are the representative types used in the South, and many of these are known to the farmers by different names.

Some varieties do much better in one locality than in another, as they are better adapted to certain soils and climate. As a general rule it is better to grow corn from seed raised in the same latitude. That grown further North will mature much earlier, and that grown further South will mature much later. Ordinarily, the question of a few days difference in the maturity does not amount to very much, as the seasons are long anyway, and there is plenty of time.

If it is desired to plant in July or August for a late crop, then it would be well to select a very early maturing variety. The late maturing varieties are large yielders. The time varies from three to six months.

As was before stated the Dent is better than the Flint.

If there is no hurry it is better to grow a variety that takes about one hundred and sixty days to mature.

The ears should at least be an average in size, well filled, and when ripe should turn down, as this will insure good keeping during a rainy spell.

The ear should be well covered with the shuck.

The roots should be strong and well able to hold the stalk up in a wind storm.

The cob should be small and the grains broad at outer end to fit well on a small cob.

Use a local variety if practicable.

HARVESTING THE CROP.

Unless the crop is very large and grown exclusively for grain the whole plant should be harvested. In most parts of the South the reverse is the practice, as the blades, or fodder as it is usually called, is pulled by hand and tied in bundles and hung on the stalks to dry. Later, it is stacked, or hauled into the barn. The grain is pulled in the fall when dry, but this fodder pulling is an expensive business,

and is often given out on shares, or "one half for the other" as it is usually called. That is, the farmer will give some one half the fodder pulled for the labor. This proves on the face of it how expensive it is to pull the fodder.

The best method is to cut the corn for stover just after the grain comes out of the doughy state or becomes hard. The harvesting should be done with a harvester if there is any considerable quantity, but if the field is small, then a common weeding hoe, with helve cut to a length of two feet, is the best implement to use. It is much cheaper and better than all the cane knives or special knives made.

Allow the corn to lie on the ground one or two days, if there is no danger of rain. After the dew is off on the first or second day put it up in shocks of about 200 stalks, using a rack or "horse" to start the shock on, consisting of a pole with two holes in one end, into which six foot sticks are thrust for legs.

After shock is built in the shape of wigwam, or cone, then pull the top in with rope and small pulley and tie with tarred twine, being careful to tie in a *bow* knot. Be sure that all the stalks are straight, as they will shed the water much better. So far so good, but right here is where many fail; when the corn shrinks, the string will become loose and thereby allows the shock to bend over, and the rain easily enters the crown, and right here is where the damage is done; for the water falling on the sides will run off, but when it falls on the crown it runs down into the heart of the shock, and rots the inner stalks. To prevent this, take one string and the rope and pulley and go round, ten days or two weeks after the shocking, and draw the heads in tight again, and tie with the extra string; then pull the bow knot of the string with which it was tied before, and take this string and pass on to the next shock, and so on until all is re-tied.

After standing in the shock about two months the ear will be found to be dry and hard, and the stalks dry and nicely cured. Haul to the barn and husk, or shuck out the corn, leaving the shuck on the stalk. Put the ears at once into the bin or crib, as there will be no trouble about heating.

Cut up the shucks, fodder and stalk, with a cutter, or a shredder, and pack away for winter. It is usually more convenient to have the cutter under a shed near the barn and run an elevator to the top of the barn.

The stover is found to constitute nearly half the value of the plant.

Of course it may be more economical in many instances to leave the corn standing, and slip-shuck the corn, then turn the cattle on the stalks and shucks.

When the fields can be grazed and the hay crop is abundant, this plan should be adopted. But if the farmer wants to make so much

feed that he will be compelled "to tear down his barns and build greater," to say nothing of buying extra stock to eat up the food, then let him try this method of curing his corn. He not only has an abundance of reasonably rich food, but all that the cattle refuse to eat will serve for bedding, and will not only keep the animals clean, but will absorb all the liquid manure.

The usual method of getting in the crop is to pull the corn in the fall and haul the ears to the barn, leaving the stalks in the field. Where grain only is needed, this method of course answers; but on the average farm it is willful waste.

If ensilage is required, then the same method for harvesting and cutting up can be used as for the stover; but the cutting should be done when the corn is in the milk state. When allowed to get too old, the ensilage heats badly and does not keep well.

Silos should be as deep as possible in proportion to their width, and they should be air-tight. No cracks nor corners, and the inside plank should be smooth and put on up and down, and not crosswise. The surface should be slick, with no projections, as the silage will settle down better.

The circular silo is the best form, as it economizes in material, and holds more to the amount of material used. Then there are no edges nor corners to contend with. The ensilage should be packed as it runs into the silo, and only the rubbish and trash left should be dumped on top.

No planks, or weight, are needed. They only help the rotting process by preventing the escape of vapors. The first few inches will spoil anyway, and if the trashy part is put on top, then that will rot in time and form an air-tight mass on top. Ensilage properly put up will make an ideal winter food, as it is succulent, and yet a good strong food in a very digestible form. Of course it is best to cut the corn as it goes into the silo. A great deal of hard and unnecessary work can be saved if the cutter and silo are conveniently arranged.

SELECTION AND IMPROVEMENT OF SEED.

There is but little improvement in corn by simply selecting it in the crib. That is better than no care, or selection at all but very little is gained. It is better to begin the selection not only on the stalks, but selection of the stalk itself. In other words, go carefully up and down the rows, cutting out the stalks not producing the required number of ears, or the right kind. The pollen on the faulty stalks will influence the good or perfect ears as much as the pollen from the best stalks.

The silk, or female part of the flower, should be influenced by the pollen from the perfect stalks only. When the ears appear, cut

down the faulty stalks, as they can be easily distinguished by that time, and the bad influence avoided. If the ears are to be selected in the field, then the tassel only need be cut off, and let the one ear come to maturity on these faulty stalks, as it will not be selected for seed anyway.

After the farmer goes carefully over the field and selects the perfect ears from the best stalks, then he should go carefully over these ears and select out the finest individual ears, and thus he is enabled to get the very best types from which to grow.

It is best to do away with end grains, as they are usually more or less damaged, and will cause the planter to drop irregularly.

PROTECTION AGAINST WEEVILS AND MOTHS.

If the corn is to be left in the field for maturity, then the shuck should remain on it when put in the crib, as it helps to protect from the weevils and moths. Especially is this true of the Angoumois grain moth (Gelechia cerealella).

The black weevil (Calandra oryzae) is more apt to come on the second year, or the following spring after the corn has been housed.

The corn should be well dried or cured before it is stored away and there will be no danger from heating. It should be put in a close rat or mouse-proof bin, closed on top as well as the sides, as the mouse is very ingenious in making an entrance. The close crib can be used very effectively to kill the weevils and moth as the bisulphide of carbon can be applied so easily. It can be sprinkled on top of the corn when the hauling is finished, or along while the hauling is going on, being careful to keep the door closed that the fumes may reach every part of the heap.

The fumes will disappear in a week or ten days, and there is no danger except from fire, as the bisulphide is very combustible.

No fire should be allowed around the crib, not even a pipe, as an explosion may occur.

About one pound of the bisulphide should be used to every one hundred bushels of corn. If the corn is free, or even comparatively free from weevils, then there is no necessity for bisulphide.

China berries and Jerusalem oak are often mixed in with the corn, but these remedies do not amount to much.

COMPARATIVE FOOD VALUE OF CORN AND OTHER CROPS.

It will be seen from the following table that this food stuff ranks high in feed value, and will always be the leading grain feed of the State.

The table was taken from N. C. Ex. Station Bulletin, No. 163, and is self-explanatory:

TABLE V.—*Showing Average Composition of Feeding Stuffs—American Analyses*

Foods.	No. of Analyses.	Percentage Composition.							Percentage of Digestible Matter.					
		Water.	Dry Matter.	Total Protein.	Fats (Eth. Extract.)	N-Free Extract.	Crude Fiber.	Ash.	Dry Matter.	Protein.	Fats.	N-Free Extract.	Crude Fiber.	Ash.
Cowpea-vine hay	13	11.90	88.10	14.43	2.49	41.22	21.54	8.42	52.15	9.31	1.34	29.14	9.24	3.79
Crimson clover hay	2	10.85	89.15	15.20	1.84	38.91	25.65	7.73	55.45	10.50	.89	28.82	12.49	4.14
Lucerne, or alfalfa hay	3	11.53	88.47	14.89	2.24	34.18	30.26	6.90	52.55	10.85	1.15	23.21	13.95	......
Red clover hay	35	11.63	88.37	12.50	2.43	40.43	26.81	6.15	45.69	6.17	1.03	23.28	12.73	......
Alsike clover hay	6	8.91	91.09	13.18	2.56	40.48	27.22	7.63	50.00	7.31	1.36	25.95	12.57	......
Soy (soja) bean silage	1	74.20	25.80	4.05	2.23	6.95	9.70	2.84	15.22	3.07	1.60	3.61	5.31	1.61
Soy bean hay	3	12.04	87.96	15.98	4.19	34.39	27.57	5.83	54.89	11.27	1.74	25.93	16.38	1.38
Peanut-vine hay	2	8.34	91.66	10.31	4.52	46.64	23.14	7.05	54.90	6.53	2.98	32.41	12.01	1.44
Corn silage, whole plant	3	71.98	28.02	2.11	.61	16.42	7.72	1.16	14.91	.73	.40	9.93	3.34	0.30
Pulled fodder, blades alone	2	8.94	91.06	11.82	3.31	41.45	24.72	9.72	54.64	5,34	1.96	26.28	17.06	2.56
Corn fodder, whole plant	11	32.19	67.81	4.81	1.28	37.15	20.21	4.32	......	2.60	.90	23.63	13.84	......
Corn stover, whole plant, minus ears	10	22.81	77.19	5.47	1.34	39.90	25.55	4.92	47.70	2.80	.69	25.29	17.04	2.18
Corn butts or stubble, portion below ears*	1	46.74	53.26	1.76	1.08	27.37	20.46	2.59	35.42	.37	.86	18.89	15.04	.30
Corn husks or shucks*	1	8.10	91.90	3.33	0.85	51.55	32.81	3.36	66.17	.98	.28	38.65	26.08	.54
Corn tops, cut above ears	2	12.19	87.81	7.96	2.44	42.16	28.03	7.22	50.32	3.08	1.62	24.37	19.87	.54
Sorghum fodder, leaves alone	1	12.43	87.57	9.60	4.55	44.93	23.93	4.56	55.25	5.84	2.12	28.98	16.84	1.34
Sorghum bagasse	2	11.25	88.75	3.44	1.44	50.47	30.52	2.88	53.78	.47	.67	32.72	19.46	.38
Timothy hay	58	10.21	89.79	6.18	2.19	46.91	30.29	4.22	51.90	3.03	1.21	30.16	16.14	1.46
Red top hay (Agrostis vulgaris)	4	9.52	90.48	7.70	2.14	46.19	28.52	5.93	52.12	4.65	.94	27.30	17.45	1.44
Orchard grass hay	6	9.80	90.20	6.82	2.38	42.12	33.23	5.63	51.68	4.08	1.29	23.42	20.40	1.95
Johnson grass hay	3	12.30	87.70	7.55	2.93	41.62	29.69	5.91	47.80	3.37	1.16	22.64	17.16	3.32
Cat tail, or pearl millet	2	10.47	89.53	9.94	1.97	36.62	30.78	10.22	55.78	6.22	.91	21.64	20.47	6.99
Mixed hays	10	15.41	84.59	6.25	2.09	40.30	31.21	4.73	45.93	2.99	1.04	22.93	14.95	......
Meadow (mixed) hay (horse)	Same composition as above								40.11	3.60	.37	23.42	12.18	......
Oat straw	13	8.84	91.16	3.80	2.29	39.12	41.23	4.72	45.85	?	.88	20.81	23.75	......

Whole raw cotton-seed	1	17.51	82.49	14.48	19.38	25 41	20.30	2 90	54.53	9 83	16 88	12 60	15.32	1 25
Whole-roasted cotton-seed	1	9.32	90.68	16 09	22 48	25 78	24.03	2.26	50 69	7.56	16 11	13.25	15 84	......
Cotton-seed meal	4	7 74	92.26	38 78	10 25	30 20	6 37	6 66	67.63	34.05	9.19	18 57	2.96	2 10
Cotton seed hulls	5	11 50	88 50	4 15	2.92	39 14	39 87	2 38	36 37	.24	2 32	13.42	18.90	.51
Wheat bran	70	12.43	87.57	15.37	3 85	53.44	9 32	5.60	51.92	11 97	2.82	35.16	1 68	......
Corn meal (cows)	63	15 61	84.39	9.12	3.93	67.92	1 99	1.45	71 39	5.32	3 61	59.16	.07	......
Corn meal (pigs)	Same composition as for cows.								75.53	7.85	3 21	63 93	.58	......
Corn (digested by horse)	Same composition as for cows.								78 01	8 09	3.32	64.30	0 84	......
Corn-meal (digested by goats)	Same composition as for cows.								71 39	5 32	3.61	59.16	......	......
Whole corn (pigs)	201	10.52	89.48	10 59	5 44	69.81	2.09	1.55	77.01	8.40	3.62	63 74	91	......
Corn-and cob meal (goats)	9	14 52	85 48	8.36	3 51	65.03	7 06	1 52	67.27	5.45	2 97	55 67	3.37	......
Corn-and cob meal (pigs)	Same composition as for goats.								64.62	6.33	2 88	54.37	2 01	......
Oats †	25	10.94	89 06	11.38	4 81	60.05	9 85	2.97	......	8.76	3 94	44.44	1 67	......
Oats (horse)	Same composition.								59 71	9.05	3.42	45 08	2 87	......
Rice bran, or douse (sheep)	5	9 65	90.35	12 07	8.76	50 04	9.51	9 97	80.63	9.33	7.82	50.04	6.39	......
Cowpea, a bean, ground (horse)	5	14 81	85.19	20.75	1.44	55 72	4.05	3.22	74 16	17.82	0.19	52 13	2 66	......
Cowpea, a bean, ground (ruminants)	Same composition as for horse.								75 72	18 27	1.17	51 09	2 91	......
Cowpea, ground (swine)	Same composition as for horse.								77.48	18.28	.70	53.86	2.77	......
Soy beans (sheep)	8	10 80	89.20	33.98	16.85	28 89	4.79	4.69	75.86	29 64	15.88	17.96	......	......
Rye bran (swine)	12	11.64	88.36	14 74	2.81	63 74	3 48	3 59	59 20	9 72	1.61	47.47	.31	......
Rice (swine)	10	12.44	87.56	7.44	0.19	79.20	0 35	0.38	86 07	6 38	.13	78.88	......	......
Potatoes (swine)	12	78 89	21.71	2 14	0.10	17 36	0.56	0.95	19.62	1.55	......	17.02	.30	......
Buttermilk	1	91 49	8 51	3 19	0 27	4.49	......	0.56	8.05	3 05	.25	4 42	......	......
Carrots (horse)	15	88 59	11.41	1.14	0.42	7 56	1 27	1.02	9 95	1.13	......	7.09	......	......
Cow's milk, composite (calves)	......	85 26	14.74	3.21	5.37	5.44	......	0.72	4 41	3.09	5.36	5.34	......	......
Crab grass hay	2	10 31	89.69	6 92	1.62	40.96	32 92	7.27	......	2.21	0 577	21 63	21.20	3.77
Cowpea meal	1	12 63	87 37	22 25	1 59	56.47	3 69	3 37	......	18 25	1 175	52.57	2.36	1.13
Rice bran	1	10 22	89.78	13 50	10.72	46.47	10.86	8 23	......	8.49	9.50	36.65	3.17	0 20
Corn bran	1	10.80	89.20	9.77	5 74	61 96	9.32	2.37	......	5 22	4.15	49.32	4 95	......
Rape (first growth)	1	81.52	18.48	4.02	0.77	8.13	2.29	2 29	......	3 64	0 42	7 63	2.06	1.75
Rape (first growth)	1	85.06	14.94	3 85	0 58	5.87	1.45	2.02	......	3 36	0.25	5.28	1 22	0.99

* Analyses from Bulletin 20, Maryland Experiment Station.

† Compilation of Dr. E. H. Jenkins, Annual Report Connecticut Experiment Station, 1888.

BULLETIN No. 172 MAY, 1900

THE NORTH CAROLINA
COLLEGE OF AGRICULTURE AND MECHANIC ARTS
AGRICULTURAL EXPERIMENT STATION DEPARTMENT
G. T. WINSTON, LL.D., DIRECTOR

The Digestibility of Some Non-Nitrogenous Constituents of Certain Feeding Stuffs.

THE PURIFICATION OF PHLOROGLUCINOL.

G. S. FRAPS
UNDER THE DIRECTION OF W. A. WITHERS, CHEMIST.

WEST RALEIGH, N. C

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Publications will be sent to any address in North Carolina upon application.

THE NORTH CAROLINA COLLEGE OF AGRICULTURE AND MECHANIC ARTS

AGRICULTURAL EXPERIMENT STATION DEPARTMENT

WEST RALEIGH, N. C.

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The Station is glad to receive any inquiries on agricultural subjects. *Address all communications to the Agricultural Experiment Station, and not to individuals.* They will be referred to the members of the Station staff most competent to answer them.

LETTER OF TRANSMITTAL.

N. C. College of Agriculture and Mechanic Arts,
Agricultural Experiment Station Department,
Division of Chemistry, Raleigh, N. C.

Sir:—The problem of animal nutrition lies at the foundation of the economic production of animals, which is one of the grand divisions of the work on the farm. Any information as to the effects of feeding stuffs on the animal body or in regard to the changes which are brought about in the feeding stuff by the animal body, will prove useful to the practical stockman, ultimately if not immediately. The observant feeder does not need to be told that by varying the relation between the amounts of concentrates and roughage, there will be a difference in the flow of milk and the amount of butter produced. Only a little thought will convince him that it is the difference in composition of the feeding stuff, which brings about such different results. For this information he must consult the chemist. The chemist has come to the aid of the stockman, and has made many analyses of the feeding stuffs and excrements, and upon the basis of these results has formulated standards for feeding animals, to produce the greatest results with the least expenditure. The value of this work is abundantly shown by the experience of the practical stockman who has adopted these standards. These standards and the analysis of our usual feeding stuffs may be found in Bulletin No. 163 of this Experiment Station.

These calculations are based upon the percentage and total amount of protein, carbohydrates, and fats digested. Additional investigations have been made showing the units of heat in the feed which have been utilized in the animal body, and still other determinations have shown the amounts of carbon, hydrogen and nitrogen which have been utilized by the body. A few experiments have been made in which there was a study of the digestibility of the sugars, some have studied the reducing sugars, others starch, and still others the digestibility of the pentosans. No previous experiments have been performed in which there was a study of the digestibility of all these constituents in the same feeding material. This Division has begun the study of the digestibility of the proximate constituents or groups of proxi-

mate constituents of feeding stuffs, and hopes to continue the work when additional material becomes available.

To Dr. Fraps, Assistant Chemist, was assigned the determination of the digestibility of the sugars, total pentosans and the pentosans in crude fiber in timothy hay, green rape and in crabgrass hay alone, and with cowpea meal, corn bran, and rice bran, which materials were left over from the experiments which are published in Bulletins 148 and 160, or in manuscript awaiting publication. From these determinations and the determination of the digestibility of starch by Sherman, he has calculated the digestibility of some other non-nitrogenous constituents, and has found that the order of digestibility is sugars, starch, pentosans, crude fiber, residual nitrogen-free extract, and pentosans in the crude fiber—the sugars and starches being practically entirely digested.

To the practical stockman these results emphasize the great value of the feeding stuffs containing large amounts of the sugars and the starches. To the student of animal nutrition they suggest the importance of determining the sugars, starches and pentosans in feeding experiments, possibly even at the sacrifice of the crude fiber determination.

Very respectfully,

W. A. Withers,
Chemist.

To Dr. Geo. T. Winston,
Director.

The Digestibility of Some Non-nitrogenous Constituents of Certain Feeding-stuffs.

G. S. Fraps, Ph.D., Assistant Chemist.

INTRODUCTION.

As is well known, the ether-extract, protein, nitrogen-free extract, and crude fiber determined in feeding-stuff analyses, are composed of various substances with different coefficients of digestibility. The ether-extract contains, besides the true fats, waxes, cholesterin, phytosterin, lecithin, hydrocarbons, coloring materials, etc. The "protein" includes proteids of varied nature, amido compounds, acid amides, organic bases, ammonia, nitrates, and other compounds which have not been studied. One of the proteids, nuclein, is entirely indigestible. The nitrogen-free extract may contain sugars, dextrines, gums, starches, pentosans, coloring matters, organic acids, so-called hemicelluloses, lignocellulose and cellulose, the two latter, as is well known, being partly dissolved by the $1\frac{1}{4}$ per cent acid or alkali. The crude fiber contains the true cellulose and the lignocelluloses which have not been dissolved by the alkali and acid.

These compounds vary in digestibility and in their usefulness to the animal body. Some possess a high coefficient of digestibility, some a low one; the digestibility of the fodder groups depends on the nature of the compounds of which they are composed.

In the work about to be described, determinations have been made of the digestibility of certain of the constituents of the nitrogen-free extract and the crude fiber. The sugars, total pentosans, and pentosans in the crude fiber, have been determined in the food and excrement from certain digestion experiments. These determinations give a basis for calculating the digestibility of the following groups: (1) sugars; (2) pentosans in nitrogen-free extract; (3) pentosans in crude fiber; (4) pentosan-free crude fiber; (5) residual nitrogen-free extract, i. e., total nitrogen-free extract less sugars and pentosans contained in it. Starch should also have been determined, but it was not undertaken.

The materials used in this work are feeding stuffs, wastes, and excrements from one digestion experiment on sheep described in Bul-

letin 148 of this Station, all described in Bulletin 160, and also one on timothy hay not yet published.

SUGARS.

All feeding stuffs contain sugars to a greater or less extent. As the sugars are generally digested completely, to subtract them from the nitrogen-free extract will lower its coefficient of digestibility.

Determinations have been made in this country on the digestibility of sugars. W. H. Jordan, J. M. Bartlett and L. H. Merrill, at the Maine Experiment Station (*a*), found that the sucrose and glucose of alsike clover, white clover, bluejoint, orchard grass, red top, timothy, wild oat grass, witch grass, buttercup, and white weed, are completely digested. E. F. Ladd, at the New York (Geneva) Experiment Station (*b*), found the sucrose and glucose to be completely digested in alfafa hay, mixed hay, wheat bran, corn meal, cotton-seed meal, linseed meal and oats; in an experiment in which turnips and mixed hay were fed, the glucose was completely digested, but the sucrose was digested to the extent of only 78.7 per cent, the excrement containing 1.20 per cent of sucrose. The writer has been unable to find an explanation for this anomalous result; true Hofmeister (*c*) has found a limit to the assimilation of sugar by dogs, the limit being 10 grains of cane sugar or 5 grains of dextrose by dogs weighing from 2.5 to 3.6 helogrammes. There may also be a limit for herbivorous animals, but the weight of sugar fed in the case above noted was exceeded in three of the other five rations, so this can not be the explanation.

At the North Carolina Station, B. W. Kilgore and F. E. Emery (*d*) found the reducing sugars digested 100 per cent in corn fodder, crimson clover hay, cowpea-vine hay, soja-bean silage, cotton seed, and cotton-seed hulls. The water-soluble polysaccharides were not determined. H. C. Sherman (*e*) found the soluble carbohydrates of wheat bran digested 96.9 per cent, the faeces containing 0.7 per cent. This is another exceptional case.

DIGESTIBILITY OF SUGARS.

A number of excrements from digestion experiments made at this station were examined to see if any exceptional case could be found in which the sugars were not completely digested. Those excrements were selected which it was thought would most probably be exceptional.

In many cases, a slight reduction of Fehling's solution occurred. The following method of examination was adopted: Three grams

a Report: 1888, 98; Agricultural Science: *2*, 300. *b* Report for 1889, 149. *c* Experiment Station Record: *11*, 461. *d* Technical Bulletin No. 4. *e* Jour. Am. Chem. Soc.: *19*, 291; Analyst: *22*, 270.

excrement was stirred with 50 cc water for one hour, filtered, and washed to a volume of nearly 200 cc. Direct treatment of this solution with the copper reagent was unsatisfactory, a blue compound insoluble in water separating usually; so basic lead acetate was added to the solution, it was made up to 200 cc., shaken and filtered. To 50 cc. of the filtrate, heated to boiling, 10 cc. of the mixed allihn reagent was added, the solution boiled and filtered as usual. For sucrose, the filtrate was inverted, etc., in the usual way.

With some of the excrements, no visible reduction of copper occurred; with the others the reduction was always very slight, the cuprous oxide only visible after the solution had been filtered and the filter washed. The precipitate could not be weighed, being at the greatest 3 mgr., so it was dissolved in nitric acid, and determined colorimetrically with potassium ferrocyanide.

The following excrements contained no sugars, and therefore, the sugars in the corresponding feeding stuffs were digested 100 per cent; 758, from crabgrass hay; 762, from crabgrass hay and pea meal; 815, from crabgrass hay and corn bran; 910 and 911, from green rape; 915, from crabgrass hay and rice bran; 1431, 1432, from cattail millet; 1433, from sorghum fodder; 1434, from crimson clover hay; 1436, from soja-bean silage.

The following excrements reduced traces of copper, corresponding to the percentage of sugars:

No.	Origin.	Reducing Sugars.	Sucrose.
763	Crabgrass hay and pea meal	0	0 06
815	Crabgrass hay and corn bran	0	0 16
913	Green rape	0 05	0.04
914	Crabgrass hay and rice bran	0	0.06
1348	Corn silage	0	0 04
1349	Corn silage	(with sucrose)	0.14
1376	Corn silage	" "	0 15
1377	Corn silage	" "	0 05
1410	Timothy hay	" "	0.06
1411	Timothy hay	" "	0.20
1435	Corn fodder	0.06	0.08
1437	Sorghum fodder	0 05	0 09

The reduction above noted may have been due to other bodies than sugars. Experiments were made to test this point. Four excrements were selected, namely: 1376 and 1377, from corn silage; 1411, from timothy hay; and 1437, from sorghum fodder.

Fifty grams of each were digested with 500 cc. cold water, filtered through linen, and washed with about 1,000 cc. water. Basic lead

acetate was then added in excess, the precipitate filtered off and washed. The filtrate was evaporated to about 25 cc., organic matter separating during the process. The lead was removed with sodium carbonate, the solution filtered, and washed to 100 cc. 25 cc., corresponding to 12.5 grams excrement, about 17 times as much as was used before, was allihned; another 25 cc. inverted with hydrochloric acid and allihned. In no case was there the slightest reduction of copper, showing the absence of sugar. We may safely conclude that the traces of copper oxide formed in the preceding experiments were due to bodies not sugar.

The following statements appear justified:

(1) Sugars in the ordinary feeding stuffs may be regarded as digested completely.

(2) Traces of reducing substances are sometimes present in excrements, but are probably not sugars.

DIGESTIBILITY OF NITROGEN-FREE EXTRACT LESS SUGARS.

A comparison between the digestibility of the entire nitrogen-free extract, and that of the nitrogen-free extract less the sugars, shows at times a considerable difference, as might be expected in the case of materials containing much sugar and a nitrogen-free extract with a low coefficient of digestibility.

A comparison is made in Table I; it is partly worked out from the

TABLE I.—*Digestibility of Nitrogen-free Extract Less Sugars.*

	(a) N-free Extract.	Ditto, less Sugars.	a—b.
New York Station:			
Alfalfa hay	71 8	68 5	3.3
Mixed hay	55 5	40.4	15.1
Mixed hay and turnips	61 4	49 2	12.2
Mixed hay, corn meal, cotton-seed meal and wheat bran	77.4	73 9	3.5
Mixed hay, corn meal, wheat bran	83.5	81.6	1.9
Mixed hay, corn meal, wheat bran, cotton-seed meal, linseed meal, oats	67.4	60.6	6.8
North Carolina Station:			
Timothy hay No. I	60 3	53 5	6.8
Green rape No. I	93 8	92 5	1.3
Green rape No. II	89 9	87.9	2.0
Crabgrass hay No. I	49 7	47.5	2 2
Crabgrass hay No. II and pea meal	76 6	74 8	1.8
Pea meal	95 4	95 0	0.4
Crabgrass hay No. I and corn bran	74 6	73 5	1.1
Corn bran	80 3	79.5	0 8
Crabgrass hay No. II and rice bran	65 9	64.6	1.3
Rice bran	80 4	79.9	0.5
Timothy hay No. II	56.2	51.1	5.1

digestion experiments made at the New York Station (Table II), already cited (Report 1889), and partly from digestion experiments made at this Station, the determination of sugar being made for this purpose, by the methods of the O. A. A. C. (Tables X-XVI).

The decrease in the digestibility of the nitrogen-free extract when the sugar is subtracted, is often considerable in the case of the fodders, and appreciable, though less, in the case of concentrated feeding stuffs. With alfalfa hay, the decrease is 3.3 per cent; 15.1 per cent with mixed hay; 6.8 per cent and 5.1 per cent with timothy hay;

TABLE II.—*Digestibility of Nitrogen-free Extract less Sugars. New York (Geneva) Station.*

	Sugars.	N-free Extract.	N-free Extract less Sugars.
A.—Alfafa hay fed (in ounces)	14 20	135 56	121.36
In excrement	0	38 26	38 26
Digested	14 20	97 30	83.10
Per cent digested	100	71.8	68.5
B.—Mixed hay fed	23.02	90.91	67.89
In excrement	0	40 45	40.45
Digested	23.02	50 46	27.44
Per cent digested	100	55 5	40.4
C.—Mixed hay and turnips fed	22.62	89 18	66 56
In excrement	1·07	34.38	33.31
Digested	21 55	32.18	33.25
Per cent digested	.....	61 4	49.2
D.—Mixed hay, corn meal, cotton-seed meal, wheat bran fed	22 23	162 72	140.49
In excrement	0	36 74	36.74
Digested	22.23	125 98	103.75
Per cent digested	100	77.4	73 9
E.—Mixed hay, corn meal, wheat bran fed	16 83	168.64	151.81
In excrement	0	27 91	27.91
Digested	16.83	140.73	123.90
Per cent digested	100	83.5	81 6
F.—Mixed hay, wheat bran, corn meal, cotton-seed meal, linseed meal, oats fed	38 01	219.08	181.07
In excrement	0	71.37	71.37
Digested	38.01	147 71	109.70
Per cent digested	100	67 4	60 6

2.2 per cent with crabgrass hay. With green rape, the decrease is 1.5 and 2 per cent; with pea meal, only 0.4 per cent; with corn bran, 0.8 per cent; with rice bran, 0.5 per cent. In the case of cotton-seed meal, the nitrogen-free extract of which, containing about 33 per cent sugar, has a digestibility of 6.15(*a*), to subtract sugars lowers it to about 42.5 per cent, a decrease of 19 per cent. These figures show the importance of determining sugars when digestion experiments are made with hay and fodders.

TABLE III.—*Sugar Content of Feeding Stuffs, on Dry Matter.*

No.		Reducing Sugars.	Soluble Polysaccharides as Sucrose.	N-free Extract.	Sugars ÷ N free Extract.
	New York Station:				
	Alfalfa hay	3 06	1.40	41.13	10.7
	Mixed hay	8.00	2 44	48 68	21.4
	Turnips	25 46	4.88	64.07	47.4
	Wheat bran	1 96	2.20	62.98	6.6
	Corn meal	0	2.40	78.62	3.1
	Cotton-seed meal	0	9 22	27.57	33.5
	Linseed meal	0.20	2 32	40 39	5.9
	Oats	1.20	0	71.75	1.7
	North Carolina Station:				
656	Timothy hay No. I	4.97	3 36	55 92	14.9
753	Crabgrass hay No. I	1 42	0.47	45.19	4.2
754	Crabgrass hay No. II	2.20	0	46.15	4.8
759	Cow-pea meal	0	5 66	64 63	8.7
812	Corn bran	2.21	0.72	69 46	4.2
820	Green rape No. I	5.22	1.81	42.49	15.2
819	Green rape No. II	4.27	4.14	46.41	19.8
917	Rice bran	0 97	0.59	51.75	3.0
*1412	Timothy hay No. II	2.06	3.24	50.22	10.5
*1359	Corn silage No. I	1.76	0.11	55 40	3.4
*1378	Corn silage No. II	2.27	0 12	50 66	4.7
*1414	Cotton-seed meal	0	7.94	24.1	32.9
*1418	Timothy hay No. III	4.81	3.75	53.6	16.0

* Not digested.

In Table III is tabulated the sugar content of the feeding stuffs used in the digestion experiments above mentioned, and also what percentage of the nitrogen-free extract is sugars. The hays contain usually a moderate amount of sugars—for example(*b*), red clover, (average of 21), contains 6.36 per cent; timothy hay (average of 21), 8.44 per cent, sorghum, 21.0 per cent, corn fodder, 3.93. Timothy sometimes contains as much as 10.73 per cent(*c*). Concentrated foods have a low percentage of sugars, with the exception of

a Bulletin 97, this Station. *b* E. F. Ladd; Am. Chem. Jour. *10*, 49. *c* Jordan, Bartlett & Merrill; Agr. Science *2*, 300.

cotton-seed meal, in which 9.22 and 7.94 per cent of sugar (raffinose) is contained, making up 33.5 and 32.9 per cent of the nitrogen-free extract. The great effect this high percentage of sugar has on the digestibility of the nitrogen-free extract has already been noted, nitrogen-free extract less sugar being digested 42.5 per cent, including sugar, 61.5 per cent, or nearly one-half more.

STARCH.

The determination of the digestibility of starch in the samples which were used for pentosans and sugars, was not made on account of lack of material. The writer has been able to find only one digestion experiment in which the digestibility of starch was determined, using the diastase method for solution of the starch. In this experiment,(*a*) with wheat bran, starch was entirely digested. A number of digestion experiments have been made in which the starch was determined by hydrolyzing it with dilute acids, but dilute acids dissolve other bodies than starch, and the figures obtained by this method can not be taken to represent the digestibility of starch. Starch probably possesses a high coefficient of digestibility. The nitrogen-free extract of many human foods, composed mainly of starch, such as flour, corn meal rise, is digested to the extent of 95 to 100 per cent; and the nitrogen-free extract of concentrated cattle foods which contain much starch possesses a high coefficient of digestion, usually above 85 per cent. Fodders and hays contain but little starch. As will be seen later, the starch in rice bran is digested at least 85 per cent, of corn bran 86 per cent, and of cowpea meal 97.4 per cent. It is more probable that the digestibility of starch is nearly 100 per cent.

PENTOSANS.

The furfural produced by distillation of feeding stuffs with hydrochloric acid, is generally ascribed to the pentosans, i. e., bodies which yield pentose sugars upon hydrolysis. The pentosans are hydrolized by dilute mineral acids to the sugars xylose and arabinose.

Other bodies than the true pentosans are found in plants which when distilled with hydrochloric acid, give rise to furfural, such as the oxycelluloses and lignocelluloses. The latter are usually described as mixtures of cellulose and non-cellulose, the non-cellulose being generally known as "encrusting matters," or "lignin." (Cross and Bevans "Cellulose," page 93.) The oxycelluloses yield from 2 to 8 per cent of furfural, the typical lignocellulose, jute, yields 9-10

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a H. C. Sherman, Jour. Am. Chem. Soc., *19*, 291.

per cent. The oxycelluloses and lignocelluloses are not true pentosans, for the reason that they are more resistant to hydrolyzing agents, and, when hydrolized, besides the pentoses other bodies are formed. We are, as yet, unable to distinguish sharply between the true pentosans, and the oxycelluloses and lignocelluloses, to which the name pseudo-pentosans may be applied. The true pentosans are presumably dissolved completely by acids and alkalies, and so are contained in the nitrogen-free extract; but the pseudo-pentosans are also partly dissolved by these reagents. The furfural from the crude fiber may be considered as originating entirely from lignocelluloses and oxycelluloses, and that from the nitrogen-free extract, while perhaps mainly from true pentosans, comes in part from pseudo-pentosans also.

DETERMINATION OF FURFURAL-PRODUCING BODIES.

Furfural-producing bodies in feeding stuffs or other materials are determined by distilling them with hydrochloric acid of 1.06 specific gravity, and determining the furfural in the distillate. Furfural has been determined by titrating with a standard solution of phenylhydrazine(*a*), using aniline acetate or Fehling's solution as an indicator, by neutralizing the solution with sodium carbonate, precipitating the furfural with phenylhydrozine, and weighing the precipitate(*b*), and by precipitating it directly with phloroglucinol(*c*), and weighing the precipitate. The volumetric method gives too high results, on account of the presence of acetone or levulinic acid (*b*); phloroglucinol as a precipitant possesses advantages over the phenylhydrazine, and is usually used.

The method used in this laboratory will here be described:

Three grams of the substance are brought into a side-neck distilling flask of about 300 cc. capacity, which is connected with a Liebig condenser, together with 100 cc. of hydrochloric acid of 1.06 specific gravity. The distillate passes through a filter paper in a small funnel into a measuring cylinder. The filter is necessary to remove fats or fatty acids, which always distil over with the furfural. Thirty cc. of fresh acid are added from a separating funnel as soon as 30 cc. have been distilled in such a manner as to wash down the particles which adhere to the sides of the flask. If the flask is placed on a wire gauze, and care taken to keep the particles washed down, there is little danger of charring on the sides of the flask. The distillation is conducted so that about 30 cc. pass over in about 10 minutes, and when 360 cc. have distilled it is discontinued. To the distillate is

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a Ber. d. deu. Chem. Ges.: *24*, 3583. *b* Landw. Versuch-Stat.: *42*, 381. *c* Chem. Zeitung: *51*, 966.

added the volume of the solution of purified phloroglucinol described in an article which follows, which contains as much phloroglucinol as furfural expected. The mixture is stirred well and allowed to stand ever night. The precipitate is then collected in a Gooch crucible, washed with 100 cc. of water, taking care not to allow it to suck dry enough for cracks to form during the washing, and the suction pump allowed to run 30 minutes after the washing is completed. It is then dried to constant weight at 100 degrees which requires from 7 to 9 hours.

For convenience in calculation, a table has been constructed showing the per cent of pentosan when three grams of substance is used. (Table IV.) It is based on the formula:

Phloroglucid (less than and up to 0.2 gram) ÷ 1.82 = furfural.
Phloroglucid (from 0.2 to 0.3 gram) ÷ 1.895 = furfural.
Phloroglucid (from 0 3 to 0.4 gram) ÷ 1.92 furfural.
Phloroglucid (above 0 4 gram) ÷ 1.93 = furfural.
Furfural—0 0104 + 1.88 = pentosan.

Values of phloroglucid less than .01 gram are not given. The interpolation can be made by dividing the weight of phloroglucid in excess of hundreths of grams by 3, and adding to the percentage given in the table.

VOLUME OF DISTILLATE.

Substances which form a precipitate with phloroglucinol continue to distill beyond 360 cc., which volume, however, is the one chosen. For example, with two samples of hay, 360 cc., then 120 cc., then 120 cc., were distilled, and the last distillates still gave a small precipitate with phloroglucinol. With bran (1491) and timothy hay (816), the furfural was determined in a second 360 cc.; bran gave 0.0040 gram phloroglucid, equivalent to 0.13 per cent pentosan if it were added to the first precipitate, and the hay 0.0126 gram or 0.42 per cent pentosan.

It is generally believed that all the furfural distils in the first 400 cc., aniline acetate being used as a test. Flint and Tollens(*a*) assume that 400 cc. is the largest quantity that will be distilled in ordinary samples. Quite possibly the compound which distills above 400 cc. is not furfural, but some other compound.

DIGESTIBILITY OF PENTOSANS.

In this country, comparatively few experiments on the digestibility of pentosans are on record. W. E. Stone(*b*) determined their digestibility in certain feeding stuffs, as follows:

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a Landw. Versuch-Station, *42*, 398. *b* Agr. Science: 7, 6; Maine Station Report: 1893, 44.

TABLE IV.—*Calculation of Pentosans.*

Wt. Ppt.	Wt. Pentosan.	Per Cent Pentosan.	Wt. Ppt.	Wt. Pentosan.	Per Cent Pentosan.	Wt. Ppt.	Wt. Pentosan.	Per Cent Pentosan.	Wt. Ppt.	Wt. Pentosan.	Per Cent Pentosan.
			.21	.1883	6.29	.41	.3799	12.66	.61	5747	19 16
			.22	.1987	6 62	.42	.3896	12.99	.62	.5844	19 48
.03	.0115	.38	.23	.2086	6 95	.43	3991	13 31	.63	.5942	19 81
.04	.0218	.73	.24	.2185	7.28	.44	.4091	13 64	.64	.6039	20 13
.05	.0322	1 07	.25	.2285	7.62	.45	.4188	13 96	.65	.6137	20 46
.06	.0125	1 42	.26	.2384	7.95	.46	.4285	14 28	.66	.6235	20.78
.07	.0529	1 76	.27	.2483	8.28	.47	4383	14 61	.67	.6332	21 11
.08	.0633	2 11	.28	.2582	8 61	.48	.4480	14.93	.68	.6430	21.43
.09	.0736	2.45	.29	.2681	8 94	.49	.4577	15.26	.69	.6528	21 76
.10	.0840	2 80	.30	.2741	9 14	.50	.4675	15 58	.70	.6626	22 09
.11	.0943	3.14	.31	.2839	9 45	.51	.4772	15 91	.71	6723	22 41
.12	.1047	3 49	.32	.2937	9.79	.52	.4870	16.23	.72	.6820	22.73
.13	.1151	3.84	.33	.5035	10 12	.53	.4967	16 56	.73	.6917	23 06
.14	1254	4 18	.34	.3133	10 44	.54	.5065	16.88	.74	.7014	23 38
.15	.1357	4 52	.35	.3231	10.77	.55	.5162	17.21	.75	.7111	23.70
.16	.1457	4 85	.36	.3329	11 10	.56	.5260	17 53	.76	.7208	24 03
.17	.1560	5.20	.37	.3427	11 42	.57	.5358	17.86	.77	.7305	24 35
.18	.1664	5 55	.38	.3525	11 75	.58	.5455	18.18	.78	.7403	24 67
.19	.1767	5.89	.39	.3623	12 08	59	.5552	18.51	.79	.7500	25 00
.20	.1870	6.23	.40	.3702	12.34	.60	.5650	18.83	.80	.7597	25 32

	Per Cent of Pentosans Digested.
Timothy hay—early bloom	60.4
Timothy hay—early bloom	54.6
Timothy hay—late cut	62.8
Timothy hay—late cut	48.2
Timothy hay	48.0
Timothy hay	49.5
Danthonia spicata	68.6
Agrostis vulgaris	70.0
Calamagrastis canadensis	90.4
Triticum repens	59.9
Hungarian grass	68.2
Trifolium hybridum	56.8
Corn fodder, Northern corn	76.6
Corn fodder, Southern corn	69.6
Timothy hay and sugar beets	71.3
Timothy hay and rutabagas	57.1
Timothy hay and wheat bran	45.6
Timothy hay and glutin meal	59.1
Agrostis vulgaris hay and wheat bran	54.1
Agrostis vulgaris hay and wheat middlings	64.9

The pentosans were determined by titrating the distillate with a standard solution of phenylhydrazine, using Fehling's solution as an indicator.

Excluding Calamagrostic canadensis, the average digestibility of the pentosans in the 19 substances, is 60.3 per cent. Stone draws the following conclusions: "While these bodies are at present classified among the carbohydrates, they are really much less digestible and hence of less food value, than the better known members of this group, as starch, sugar, etc. In many cases the indicated digestibility is even less than that assigned to the fiber of the same materials, and the average of all the experiments is but little higher than the corresponding average for the fiber. Indeed, from the data at hand it would appear that of all the food constituents capable of individual estimation, these are among the less soluble in the digestive fluids, although commonly included among those substances which are regarded as in a high degree digestible."

J. B. Lindsay and E. B. Holland* have determined the digestibility of the pentosans in the following materials, using the method of weighing the phenylhydrazine precipitate:

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* Agricultural Science, *8*, 172.

	Per Cent of Pentosans Digested.
Hay of mixed grasses (a)	63
Hay of mixed grasses (b)	62
Buffalo gluten feed	78
New process linseed meal	89
Old process linseed meal	84
Corn cobs	62
Dried brewers' grains	55
Spring wheat bran	62
Winter wheat bran	64

The average coefficient is 68.8 in the above table.

In six out of nine cases, they state, the pentosans are practically as digestible as any other of the groups of fodder substances. "With the more concentrated foods it will be observed that the pentosans are as digestible as either the fat, protein, or extract matter. *The results make clear that association has a great deal to do with digestibility.* In the hays, corn cobs, and brewers' grain, where the woody substance (lignin) is present to a considerable extent, the digestibility of the pentosans is noticeably less than when the incrusting substance is absent. Whether or no the pentosans are chemically united to the incrusting substance is not known, but it is not at all improbable."

H. C. Sherman (Jour, Am. Chem. Soc. 19, 308) found the digestibility of true pentosans to be 66.2 per cent in wheat bran.

Determinations of total pentosans have been made in the feeding stuffs, wastes, and excrements which were used in determining the digestibility of the nitrogen-free extract less sugars. The determinations were in duplicate, by the method already described. The complete composition of the excrements, wastes, and feeding stuffs is tabulated in Table V. The digestibility of the pentosans are worked out in Tables X—XVII, in the back of this bulletin. In Table VI is a comparison of the digestibility of total pentosans and of the other fodder groups. The figures for fats, protein, nitrogen-free extract are worked out in Bulletins 140 and 160 of this Station.

There is no regularity in the relation of the digestibility of the total pentosans to the other fodder groups visible in this table. The pentosans in green rape have a very high coefficient, those in cowpea meal and corn bran come next, and the hays and rice bran are last in order.

The average digestibility of the pentosans in the feeding stuffs tabulated in Table VI is 68.5 per cent. The average for all the materials (34) cited in this paper is 64.2 per cent. The average for the pentosans in the timothy hay (8 samples) is 53.9.

TABLE V.—*Composition of Feeding Stuffs, Wastes and Excrements on Dry Matter.*

Old No.	New No.		Sugars.	Total Pentosans.	True Pentosans.	Pseudo-Pentosans.	Residual N-free Ext.
656	1452	Timothy hay No. I	8.33	24 86	19 71	5.15	16.88
753	1455	Crabgrass hay No. I	1.89	26 25	21.90	4 35	21.40
754	1456	Crabgrass hay No. II	2 20	24.71	19 85	4.85	24 09
759	1461	Cowpea meal	5.66	6.83	6 83	0	52.20
812	1480	Corn bran	2.93	25 15	25.15	0	41.36
819	1463	Green rape No. I	8.41	10.57	9 57	1.00	29 81
820	1485	Green rape No. II	7 03	8.71	8.04	0.67	26 04
917	1490	Rice bran	1.56	10.88	9 88	1 00	40.31
1412	1474	Timothy hay No. II	5 30	26 29	20.91	5.38	-------
*1418	1476	Timothy hay No. III	8 56	23 52	-------	-------	-------
*1359	--	Corn silage No. I	1.87	22 71	-------	-------	-------
*1378	1469	Corn silage No. II	2 39	20.68	-------	-------	-------
*1414	1475	Cotton-seed meal	7.94	7.83	-------	-------	-------
661	1453	Excrement	0	24.24	18.31	5.93	-------
663	1454	Waste	(1)	22.22	16 87	5.35	-------
755	1457	Excrement	0	25.77	20 96	4 81	-------
756	1458	Waste	-------	25 06	21 21	3 85	-------
757	1459	Excrement	-------	20 79	17 84	2 95	-------
758	1460	Excrement	-------	22.36	18.78	3 58	-------
762	1479	Excrement	-------	18.54	15 20	3 34	-------
763	1462	Excrement	-------	18.31	16 01	2.30	-------
813	1481	Waste	-------	21.64	21.64	0	-------
815	1482	Excrement	-------	23.73	21.46	2.27	-------
817	1483	Waste	-------	20 77	20.77	0	-------
818	1484	Excrement	0	24 55	22 56	1 99	-------
910	1486	Excrement	0	3 84	2.99	0 85	-------
911	1487	Excrement	0	3 61	2.76	0 85	-------
912	1465	Excrement	0	4.78	3 46	1.32	-------
913	1466	Excrement	0	5.11	3.74	1.37	-------
914	1488	Excrement	0	17 48	14.85	2.63	-------
915	1489	Excrement	0	19 31	16.13	3 18	-------
1410	1472	Excrement	0	23 81	18.61	5 20	-------
1411	1473	Excrement	0	23.78	18.38	5.40	-------

* Not digested.

(1) Wastes *assumed* to contain same per cent sugars as feeding stuffs. Wastes not in table assumed to have same composition as feeding stuffs.

TABLE VI.

	Ether Extract.	Protein.	N free Extract.	Crude Fiber.	Pentosans.
Timothy hay No. I	22	34	60	52	56
Timothy hay No. II	42	21	56	54	56
Green rape (early) No. I	54	90	94	90	95
Green rape (later) No. II	43	89	90	84	92
Crabgrass hay No. I	36	32	50	67	63
Crabgrass hay No. II and cowpea meal	55	71	77	64	66
Cowpea meal	74	82	95	39	76
Crabgrass hay No. I and corn bran	69	49	75	60	69
Corn bran	72	54	80	51	72
Crabgrass hay No. I and rice bran	82	52	66	56	60
Rice bran	89	63	80	19	54

DISTRIBUTION AND DIGESTIBILITY OF PENTOSANS.

A rough division of the total pentosans has already been made: those contained in the nitrogen-free extract, and those in the crude fiber. The latter consist of oxycelluloses and lignocelluloses; the former are perhaps for the most part made up of pentosans, but contain oxycelluloses and lignocelluloses, since these too are sometimes soluble in the acid or alkali.

These two groups of bodies possess different coefficients of digestibility, as will be seen.

The total pentosans less those in the crude fiber, gives the pentosans in the nitrogen-free extract. The crude fiber was prepared according to the methods of analysis of the Association of Official Agricultural Chemists, using, however, 3 grams material, and 300 cc. of caustic soda and of sulphuric acid instead of 2 grams and 200 cc. The last filtration was made on asbestos, the fiber transferred to a side-neck distilling flask, and pentosans in it determined as already described. The asbestos gave rise to severe bumping, which moderated when broken glass was added.

The composition of the hays, etc., is tabulated in Table V. The digestibility of the constituents is worked out in Tables X—XVII. In Table VII is tabulated the mean figures for the distribution and digestibility of the pentosans. From 78 to 100 per cent of the total pentosans are contained in the nitrogen-free extract. Corn bran and cowpea meal contain no pseudo-pentosans, so the digestibility of the pseudo-pentosans in the rations in which they were fed may be compared directly with their digestibility in the crabgrass hay fed alone. These figures are: Crabgrass hay alone, 69.9 per cent pseudo-pentosans digested; with corn bran, 46.3 per cent; with rice bran 60.3.

The results for crabgrass hay alone are plainly anomalous.

In all cases save one, the pseudo-pentosans are less digestible than the pentosans in the nitrogen-free extract. The difference is not, as a rule, as great as might be expected. The hays contain about 20 per cent of their pentosan in the crude fiber; in timothy hay, the pseudo-pentosans (lignin, oxycellulose) are digested on the average, 14 per cent less than the true pentosans; the same is true of green rape.

TABLE VII.—*Distribution and Digestibility of Pentosans.*

		Of 100 parts total pentosan.		Digestibility.			True—Pseudo (a-b.)
		True Pent.	Pseudo Pent.	Of Total.	(b) Of True.	(b) Of Pseudo Pent.	
656	Timothy hay No. I	79.3	20.7	55.8	58.1	46.9	11.2
1412	Timothy hay No. II	79.5	20.5	55.9	57.0	52.0	5.0
753	Crabgrass hay No. I	81.6	18.4	63.1	61.0	69.9	—8.8
754	Crabgrass hay No. II	80.4	19.6	------	------	------	------
759	Cowpea meal (1)	100	0	76.1	76.1	------	------
812	Corn bran (1)	100	0	71.6	71.6	--	------
819	Green rape No. I	90.5	9.5	94.6	95.7	84.6	11.1
820	Green rape No. II	92.3	7.7	91.9	93.2	75.9	17.3
917	Rice bran (1)	90.8	9.2	53.5	57.3	------	------
	Rations:						
------	Crabgrass hay No. II and cowpea meal	------	----	65.9	66.5	62.5	4.0
------	Crabgrass hay No. I and corn bran	------	------	69.2	70.4	46.3	24.1
------	Crabgrass hay No. I and rice bran	------	------	60.4	60.4	60.3	0.1

(1) Digestibility calculated from rations below.

COMPOSITION AND DIGESTIBILITY OF NITROGEN-FREE EXTRACT.

The nitrogen-free extract has been divided into the three groups: Sugars, pentosans, and residue, in these experiments. The composition and digestibility of the nitrogen-free extract is exhibited in Table VIII. In the hays and in green rape, the pentosans are more digestible than the residue, coming next to the sugars. In the cowpea meal, corn bran, and rice bran, the residue is digested to a greater extent than the pentosans, but this residue consists for the most part of starch, so that we may say that starch is more digestible than pentosans; and that the starch of cowpea meal must be 97.4 per cent digested, of corn bran 86.1 per cent, of rice bran 85. per cent, at the

least. The components of the nitrogen-free extract may therefore be arranged in the following order, according to their digestibility: (1) sugars, (2) starch, (3) pentosans, (4) residue.

TABLE VIII.—*Composition and Digestibility of Nitrogen free Extract.*

		IN 100 PARTS.			DIGESTIBILITY.		
		Sugars.	Pentosans.	Residue.		Pentosans.	Residue.
656	Timothy hay No. I	14.9	35.2	49.9	Sugars 100 per cent.	58.1	50.1
1412	Timothy hay No. II	10.5	41.6	47.9		57.0	46.0
753	Crabgrass hay No. I	4.2	48.4	47.4		61.0	32.7
754	Crabgrass hay No. II	4.8	43.0	52.2		-----	------
759	Cowpea meal	4.8	10.6	84.6		76.1	97.4
812	Corn bran	4.2	36.2	59.6		71.6	86.1
819	Green rape No. I	15.2	20.6	64.2		95.7	91.4
820	Green rape No. II	19.8	18.9	61.3		93.2	86.5
917	Rice bran	3.0	19.1	77.9		57.3	85.0

COMPOSITION AND DIGESTIBILITY OF CRUDE FIBER.

Crude fiber may be divided into two groups: Pseudo-pentosans, and residual crude fiber. The composition and digestibility of the crude fiber is exhibited in Table IX. The pseudo-pentosans are, with one exception, less digestible than the crude fiber, the difference between the coefficients of digestion of pseudo-pentosans and residual

TABLE IX.—*Composition and Digestibility of Crude Fiber.*

		100 PARTS CRUDE FIBER CONTAINS		DIGESTIBILITY OF			Residual N-free Extract.
		Pseudo Pentosans.	Residue.	Total Crude Fiber.	Pseudo Pentosans.	Residue Crude Fiber.	
656	Timothy hay No. I	9.2	90.8	52.3	46.9	53.3	50.1
1412	Timothy hay No. II	14.4	85.6	53.8	52.0	54.1	46.0
753	Crabgrass hay No. I	13.0	87.0	67.3	69.9	67.0	32.7
754	Crabgrass hay No. II	13.4	86.6	------	------	------	------
759	Cowpea meal	0	100	39.2	......	39.2	97.4
812	Corn bran	0	100	50.8	--	50.8	86.1
819	Green rape No. I	7.7	92.3	90.0	84.6	90.4	91.4
820	Green rape No. II	6.3	93.7	84.0	75.9	84.6	81.5
917	Rice bran	8.3	91.7	19.1	......	19.1	85.0

crude fiber being, for timothy hay No. I, 6.4; No. II, 2.1; green rape No. I, 5.8; No. II, 8.7; crabgrass hay, 2.9.

Since crude fiber consists of oxycelluloses, lignocelluloses, and cellulose, and the "pseudo-pentosans" are in the two former, this means that the cellulose is more digestible, which agrees with experiments which prove that the portion of the crude fiber digested has very nearly the composition of cellulose.

The residual crude fiber is more digestible than the nitrogen-free extract in the timothy hay and crabgrass hay, and slightly less so in the green rape, and very much less in the cowpea meal, corn bran, and rice bran. The residual nitrogen-free extract of the last three substances is composed for the most part of starch.

DIGESTIBILITY OF CRUDE FIBER.

The crude fiber of hays is often found to have as great, or a greater, apparent coefficient of digestion as the nitrogen-free extract. If we subtract the sugar and pentosans from the nitrogen-free extract of the hays, the residue is 4.4 per cent (timothy hay No. 1), 12 per cent (timothy hay No. 2) and 47 per cent (crabgrass hay No. 1) less digested than the crude fiber.

It is assumed, in digestion experiments, that those fodder groups which are not digested, pass through unchanged, an assumption which must be modified for the nitrogenous matters and the ether extract, since products of metabolism appear in the excrement which fall into these groups. It is quite possible that the crude fiber undergoes a change in the intestines which renders it soluble in acids or alkalies, and therefore a portion of the nitrogen-free extract, thus making the digestibility of the crude fiber greater than it should be, and of the nitrogen-free extract less so. Crude fiber fed to an animal may disappear in several ways:

(1) By formation of soluble compounds, and resorbtion.

(2) By complete decomposition to carbon dioxide and marsh gas.

(3) By decomposition with the formation of soluble products, which are resorbed, and carbon dioxide or marsh gas.

(4) By decomposition with formation of products which are not resorbed and are soluble in hot alkali or acids.

The disappearance of crude fiber in digestion is generally believed to be due to the action of bacteria, the crude fiber being converted to gases, or to gases and soluble products and resorbed. According to the experiments of G. Kuhn, for every 100 parts of cellulose and nitrogen-free extract digested by steers, 4.5 parts, or 1-7 of the carbon, appears as marsh gas. The nitrogen-free extract takes part in this action as well as the crude fiber.

Besides the sugars, starches, gums, etc., the nitrogen-free extract of hays is composed of the less resistant portions of the cell walls, partly made up of pentosans. The crude fiber is the older, and more resistant portion of the cell walls, so that our digestion experiments seem to show that the older and more resistant cellular structures are in many cases digested to a greater extent than the younger and less resistant. To avoid this difficulty, it has been assumed that the more resistant portions are converted by bacteria into gases, or gases and soluble products which are resorbed. This may be, in part, true, but it can not be all the truth; since, according to Kuhn, the nitrogen-free extract takes part in the formation of gases, and we would naturally suppose them to be attacked first, unless, like starch and sugar, they are quickly rendered soluble and digested. With this hypothesis, the nitrogen-free extract should still be digested to a greater extent. The explanation appears to be that the nitrogen-free extract is more digested than the crude fiber; that the crude fiber and undigested nitrogen-free extract, remaining several days in the intestines, under favorable conditions for the action of bacteria, are decomposed, with formation of gases, of soluble products which are resolved, and of insoluble products (humus-like substances) which pass into the excrement, and, being soluble in alkalies or acids, are classed with the nitrogen-free extractives. Action like this would lower the digestibility of the nitrogen-free extract, and raise that of the crude fiber. If we could determine the digestibility of the constituents of the nitrogen-free extract one by one by a method which would not include the decomposition products of the crude fiber, if the hypothesis above stated is true, there would be a portion of the "nitrogen-free extract" in the excrement which would come from the crude fiber, and not be undigested portions of the nitrogen-free extract.

ANALYSIS OF FEEDING STUFFS.

The ash, nitrogenous matters, and ether extract are here left out of consideration. E. Schulze* has proposed that in addition to the determination of crude fiber, the non-nitrogenous matters insoluble in ether, alcohol, water, and diastase solution be determined. Fats, lecithin, starch, soluble carbohydrates, amides, soluble proteids, etc., would go in solution, and the residue would consist essentially of the material of cell walls, insoluble proteids, and a portion of the ash. It is corrected for the proteids and ash, and the crude fiber subtracted. Thus a division is made between the soluble and easily digestible nitrogen-free extract and the insoluble carbohydrates.

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*Landw. Versuch-Stationen, *49*, 434.

Where time is not available to determine sugars, starch, and pentosans, the above suggestion of E. Schulze should be adopted, even if the determination of crude fiber has to be left out altogether. The digestibility of the crude fiber does not differ, in the case of hays, greatly from that of the nitrogen-free extract.

The work which has been described in these pages shows that the nitrogen-free matters may be arranged in the following general order, according to their digestibility: (1) sugar, (2) starch, (3) true pentosans, (4) crude fiber, (5) residual nitrogen-free extract, (6) pseudo-pentosans. The determination of sugar and total pentosans is more important in coarse feeding stuffs than that of crude fiber; and of sugar, starch, and pentosans more important than of crude fiber in concentrated feeding stuffs. In digestion experiments, it would be better to determine sugar, starch, and pentosans in the feeding stuffs and excrements directly, than to follow the suggestion of E. Schulze, and determine the ether-alcohol-water-diastase insoluble portions. The latter, in the case of excrements, would include any of the nitrogen-free extract or crude fiber rendered water soluble by fermentation or other action in the animal, which would be excluded by the former method.

SUMMARY.

(1) Sugars are found in all feeding stuffs, sometimes in large percentages are completely digested, and their determination is of importance in the case of hays and cotton-seed meal.

(2) Subtraction of sugars from the nitrogen-free extract of hays reduces its digestibility appreciably. With concentrated feeding stuffs the reduction is slight.

(3) The average digestibility of total pentosans in 36 samples is 64.2. The average for timothy hay (8 samples), is 53.9.

(4) The total pentosans are distributed between the nitrogen-free extract and the crude fiber. The former are here called true pentosans, the latter pseudo-pentosans.

(5) The true pentosans have a higher coefficient of digestibility than the pseudo-pentosans. They form from 79.3 to 100 per cent of the total pentosans.

(6) True pentosans and sugars make up from 22 to 52.6 per cent of the nitrogen-free extract.

(7) The constituents of the nitrogen-free extract can be arranged in the following order according to their digestibility: (1) sugar, (2) starch, (3) pentosans, (4) remainder.

(8) Crude fiber may be divided into pseudo-pentosans and residue. The pseudo-pentosans make up from 0 to 14.4 per cent of the crude fiber, and are less digestible, as a rule.

(9) Crude fiber of coarse feeding stuffs is often digested to a greater extent than nitrogen-free extract. This may be due to decomposition of crude fiber into substances soluble in alkalies and acids, which pass into the excrement, and hence make the digestibility of crude fiber appear greater, of the nitrogen-free extract less than it really is.

(10) It is more important to determine carbohydrates soluble in ether, alcohol, water, and diastase solution, as suggested by E. Schulze, than to determine crude fiber, when conclusions as to the quality of feeding stuff is the object.

(11) The determinations of sugars, starch, and total pentosans are more important than that of crude fiber, especially in digestion experiments.

Purification of Phloroglucinol.

G. S. FRAPS, PH. D., Assistant Chemist.

The methods of analysis adopted by the Association of Official Agricultural Chemists require the use of a phloroglucinol free from diresorcinol in the determination of pentosans. According to Kruger and Tollen(*a*), small quantities of diresorcinol do not affect the accuracy of the determination; Councler(*b*) found Merck's phloroglucinol purissimum to contain from 7.5 to 14.6 per cent of diresorcinol, and concludes that it varies greatly in composition, and often contains enough diresorcinol to vitiate the results. Councler believes that it is better to add the phloroglucinol in the solid form, in order to keep the volume of the liquid as small as possible.

If the phloroglucinol is added in the solid form, only that free from diresorcinol can be used, as the latter compound is soluble only with difficulty in hydrochloric acid of 1.06 specific gravity. Phloroglucinol can be purified by dissolving it in hydrochloric acid of 1.06 specific gravity, and allowing the diresorcinol to crystallize out. The phloroglucinol remaining in solution is sufficiently pure to give the same results as Merck's phloroglucinol free from diresorcinol.

The method of purification is as follows: About 300 cc. hydrochloric acid 1.06 sp. gr., is heated in a beaker, 11 grams commercial phloroglucinol added, with stirring, and the heating continued until it has almost all dissolved. Some impurities resist solution, and they may be disregarded. Pour the hot solution into sufficient of the same hydrochloric acid to make the volume 1,500 cc. Let stand at least one night (better several days), to allow the diresorcinol to crystallize out, and filter immediately before using. The solution may turn yellow, but this does not interfere with its usefulness. One hundred cc. of hydrochloric acid 1.06 sp. gr., dissolves 0.7 gram of pure phloroglucinol.

A comparison of the phloroglucinol solution above described with the phloroglucinol free from diresorcinol of Merck, shows them to give the same results. For example, on three solutions of furfural, the weights of precipitates were, using phloroglucinol:

	I	II	III
(*a*) Purified as above	0.4575 gram.	0.5115	0.4647
(*b*) Merck's free from diresorcinol	0.4620	0.5124	0.4671

which is as close as might be expected.

a Zeits. Angew. Chem. 1896, 40. *b* Chem. Zeit. *21*, 2; Analyst *22*, 106.

TABLE X.—* *Nutrients Consumed and Excreted, with Percentages Digested.*

SHEEP NO. 1.

Number.		Total Dry Matter.	Total Sugars.	Nitrogen free Extract.	N Free Extract less Sugars.	Total Pentosans.	Pentosans in N-Free Extract.	N-Free Extract less Pentosans and Sugars in it.	Crude Fiber.	Pentosans in Crude Fiber.	Crude Fiber less Pentosans in it.	Pentosans left by 2.22 per cent Acid.
656	Timothy hay No. I fed	11 02.1	924.8	6208.3	......	2760.0	......	......	3602.6	571.8	......	167.6
663	Waste hay.....................	1231.8	102.7	6 3 1	..	273.7	......	......	407.2	65.9	......	25.7
	Consumed	9870.3	822.1	5555.2	4733.1	2186.3	1980.4	2752.7	3195.4	505.9	2689.5	141.9
661	Excrement	4528.4	0	2203.1	2203.1	1097.7	829.2	1373.9	1524.3	268.5	1255.8	92.4
	Digested	......	822.1	3352.1	2530.0	1388.6	1151.2	1378.8	1671.1	237.4	1433.7	49.5
	Per cent digested	......	100	60.3	53.5	55.8	58.1	50.1	52.3	46.9	53.3	34.2

*See Table II, Bulletin 148.

TABLE XI.—**Nutrients Consumed and Excreted in Grams, with Percentages Digested.*

SHEEP No. 3.

Number.		Total Dry Matter.	Total Sugars.	Nitrogen-free Extract.	N Free Extract less Sugars.	Total Pentosans.	Pentosans in N-Free Extract.	N Free Ext. act less Pentosans and Sugars in it.	Crude Fiber.	Pentosans in Crude Fiber.	Crude Fiber less Pentosans in it.
753	Crab-grass hay No. I fed	8095.9	153.0	3658.5	......	2125.1	......	......	3007.6	391.0	......
755	Waste	2845.8	53.8	1361.4	......	733.4	......		1016.8	136.9	......
	Consumed	5250.1	99.2	2297.1	2197.9	1381.7	1127.6	1070.3	1990.8	254.1	1736.7
757	Excrement	2399.0	0	1195.4	1195.4	498.8	428.0	767.4	623.7	70.8	552.9
	Digested	2851.1	99.2	1101.7	1002.5	882.9	699.6	302.9	1367.1	183.3	1183.8
	Per cent digested	54.31	100	48.0	45.6	63.9	62.0	28.3	68.6	72.1	68.2

SHEEP No. 4.

Number.		Total Dry Matter.	Total Sugars.	Nitrogen-free Extract.	N Free Extract less Sugars.	Total Pentosans.	Pentosans in N-Free Extract.	N Free Ext. act less Pentosans and Sugars in it.	Crude Fiber.	Pentosans in Crude Fiber.	Crude Fiber less Pentosans in it.
753	Crab-grass hay No. I fed	8095.9	153.0	3658.5	......	2125.1	......	......	3007.6	391.0	......
756	Waste	881.2	16.7	401.8	......	220.8	......	......	318.0	33.9	......
	Consumed	7214.7	136.3	3256.7	3120.4	1904.3	1547.2	1573.2	2689.6	357.1	2332.5
758	Excrement	3214.3	0	1584.0	1584.0	718.7	603.6	980.4	914.5	115.1	799.4
	Digested	4000.4	136.3	1672.7	1536.4	1185.6	943.6	592.8	1775.1	242.0	1533.1
	Per cent digested	55.5	100	51.4	49.3	62.2	60.0	37.1	66.0	67.8	65.7
	Mean per cent digested	......	100	49.7	47.5	63.1	61.0	32.7	67.3	69.9	67.0

* See Table II, Bulletin 160.

TABLE XII.—* *Nutrients Consumed and Excreted in Grams, with Percentages Digested.*

SHEEP NO. 3.

Number.		Total Dry Matter.	Total Sugars.	Nitrogen-free Extract.	N Free Extract less Sugars.	Total Pentosans.	Pentosans in N Free Extract.	N-Free Extract less Pentosans and Sugars in it.	Crude Fiber.	Pentosans in Crude Fiber.	Crude Fiber less Pentosans in it.
754	Crab-grass hay No. II fed	4088 8	90 0	1887.0	......	1010.3	1812.0	......	1482 2	198.3	......
759	Cow-pea meal fed	3963 1	224.3	2561 4	...	270.7	270 7	......	107.2	0	......
	Total fed	8051 9	314.3	4448 4	...	1281.0	1082 7	......	1649.4	198 3	......
760	Waste hay	317 0	7 0	149.6	......	78.3	63 0	......	109 8	15 3	......
	Consumed	7734.9	307.3	4298.8	3991 5	1202 7	1019.7	2971 8	1539 6	183 0	1356.6
762	Excrement	2170.9	0	976.5	976.5	402.5	330 0	646.5	546 6	72 5	474.1
	Digested	5564 0	307.3	3322.3	3015 0	800 2	689 7	2325.3	993 0	110 5	882 5
	Digested from Crab-grass hay	2070.7	83 0	863 4	780.4	587 1	476 6	303 8	923.6	110 5	813 1
	Digested from cow pea meal	3493.3	224.3	2458.9	2234.6	213 1	213.1	2021.5	69.4	...	69.4
	Per cent ration digested	71.9	100	77.3	75.6	66.5	67.6	78.3	64.5	60 4	65 0
	Per cent cow-pea meal digested	88.0	100	96 0	95.6	78 7	78.7	97.8	41.5	......	41.5

*See Table III, Bulletin 160.

TABLE XII.—*Continued.*

SHEEP NO. 4.

Number.		Total Dry Matter.	Total Sugars.	Nitrogen-free Extract.	N Free Extract less Sugars.	Total Pentosans.	Pentosans in N-Free Extract.	N Free Extract less Pentosans and Sugars in it.	Crude Fiber.	Pentosans in Crude Fiber.	Crude Fiber less Pentosans in it.
754	Crab grass hay No. II fed	4088.8	90.0	1887.0	......	1010.3	......	......	1482 2	198 3	......
759	Cow-pea meal fed	3963.1	224.3	2561.4	......	270.7	......	2066.4	167.2	0	......
	Total fed	8051.9	314.3	4448.4	......	1281.0	1082.7	......	1649.4	198.3	......
761	Waste hay	23.5	.5	9.2	......	5.8	4.8	......	8.3	1.0	......
	Consumed	8028 4	313.8	4439.2	4125.4	1275.2	1077.9	3047.5	1641 1	197 3	1443.8
763	Excrement	2425 2	0	1075.3	1075.3	444.0	374.2	701.1	587.6	69.8	517.8
	Digested	5603.2	313 8	3363 9	3050.1	831.2	703.7	2346 4	1053 5	127.5	926.0
	Digested from crab-grass hay	2231.8	85.5	935.5	846.0	632.6	505.1	340 9	991 9	127.5	864.4
	Digested from cow-pea meal	3371.4	224.3	2428.4	2204.1	198 6	198.6	2005 5	61.6	......	61.6
	Per cent ration digested	69.8	100	75.8	73.9	65.2	65.3	77.0	64 2	64.6	64.1
	Per cent cow-pea meal digested	851.7	100	94.8	94.3	73.4	73.4	97.0	36.9	......	36.9
	Mean per cent ration digested	70 9	100	76.6	74.8	65.9	66.5	77.7	64.4	62.5	64.6
	Mean per cent meal digested	86.7	100	95.4	95.0	76.1	76.1	97.4	39.2	......	39.2

TABLE XIII.—* *Nutrients Consumed and Excreted in Grams, with Percentages Digested.*

SHEEP NO. 3.

Number.		Total Dry Matter.	Total Sugars.	Nitrogen-free Extract.	N-Free Extract less Sugars.	Total Pentosans.	Pentosans in N-Free Extract.	N Free Extract less Pentosans and Sugars in it.	Crude Fiber.	Pentosans in Crude Fiber.	Crude Fiber less Pentosans in it.
753	Crab-grass hay No. I fed	3035.6	57.4	1371.9	......	796.8	......	......	1127.8	146.6	......
812	Corn bran fed	7080.7	209.5	4918.3	......	1780.8	......	......	739.9	0	......
	Total fed	1011.6	264.9	6290.2	......	2577.6	......	......	1867.7	146.6	......
813	Waste bran	1126.8	33.0	727.0	......	243.8	......	......	118.0	......	......
814	Waste hay	309.7	5.8	145.6	......	81.3	......	......	107.8	15.0	......
	Consumed in crab-grass hay	2726.2	51.6	1226.3	1174.7	715.5	573.9	600.8	1020.0	131.6	888.4
	Consumed in corn bran	5953.9	174.5	4191.3	4016.8	1537.0	1537.0	2479.8	621.9	......	621.9
	Total consumed	8680.1	226.1	5417.6	5191.5	2252.5	2120.9	3011.6	1641.9	131.6	1510.3
815	Excrement	2971.8	0	1463.3	1463.3	705.2	637.7	725.6	635.4	67.5	567.9
	Digested	5708.3	226.1	3957.3	3728.2	1547.3	1483.2	2346.0	1006.5	64.1	942.4
	Digested from crab grass hay	1496.7	51.6	609.5	557.9	451.4	387.3	170.6	686.5	64.9	622.4
	Digested from corn bran	4211.6	174.5	3344.8	3170.3	1095.9	1095.9	2175.4	320.0	......	320.0
	Per cent ration digested	62.75	100	73.0	71.8	68.7	69.9	76.4	61.4	48.7	62.4
	Per cent corn bran digested	70.77	100	79.8	78.8	71.3	71.3	87.7	51.4	......	51.4

*See Table IV, Bulletin 160.

TABLE XIII.—*Continued.*

SHEEP NO. 4.

Number.		Total Dry Matter.	Total Sugars.	Nitrogen free Extract.	N-free Extract less Sugars.	Total Pentosans.	Pentosans in N-free Extract.	N-free Extract less Pentosans and Sugars in it.	Crude Fiber.	Pentosans in Crude Fiber.	Crude Fiber less Pentosans in it.
753	Crabgrass hay No. I fed	3035.9	57.4	1371.9	......	796.8	....	....	1127.8	146.6	......
812	Corn bran fed	7080.7	207.5	4918.3	....	1780.8	....	....	739.9	0	....
	Total fed	10116.6	264.9	6290.2	....	2577.6	....	....	1867.7	146.6	....
817	Waste bran	1326.8	38.9	458.7	....	275.6	....	....	157.2	0	....
816	Waste hay	1158.5	21.9	558.0	....	240.4	....	....	392.8	56.0	....
	Consumed in hay	....	35.5	813.9	778.4	556.4	465.8	312.6	582.7	90.6	492.1
	Consumed in bran	......	168.6	4459.6	4291.0	1505.2	1505.2	2785.8	735.0	0	735.0
	Total consumed	7631.3	204.1	5273.5	5069.4	2061.6	1971.0	3098.4	317.7	90.6	1227.1
818	Excrement	2554.1	0	1263.0	1263.0	627.0	576.2	686.8	552.7	50.8	501.9
	Digested	4046.5	204.1	4010.5	3806.4	1434.0	1394.8	2411.6	765.0	39.8	725.2
	Digested from hay	1030.7	35.5	404.5	369.0	351.0	311.2	57.8	473.3	39.8	433.5
	Digested from bran	4046.5	168.6	3606.0	3437.4	1083.6	1083.6	2353.8	291.7	0	291.7
	Per cent ration digested	66.5	100.	76.1	75.1	69.6	70.8	77.8	58.1	43.9	60.0
	Per cent bran digested	70.3	100	80.8	80.1	71.9	71.9	84.4	50.1	......	50.1
	Mean per cent for ration	....	100.	74.6	73.5	69.2	70.4	77.1	59.8	46.3	61.7
	Mean per cent for bran	....	100.	80.3	79.5	71.6	71.6	86.1	50.8	....	50.8

TABLE XIV.—**Nutrients Consumed and Excreted in Grams, with Percentages Digested.*

SHEEP NO. 3.

Number.		Total Dry Matter.	Total Sugars.	Nitrogen-free Extract.	N-free Extract, less Sugars.	Total Pentosans.	Pentosans in N-free Extract.	N-free Extract less Pentosans and Sugars in it.	Crude Fiber.	Pentosans in Crude Fiber.	Crude Fiber less Pentosans in it.
819	Green rape No. I fed	7543.2	634.4	3500.8	......	797.2	......	......	985 1	75 4	......
824	Waste rape	12.	1.0	6.6	......	1.2	......	......	2.1	.1	......
	Consumed	7531.2	633.4	3494.2	2860 8	796.0	720.7	2140 1	983.0	75.3	907.7
913	Solid excrement	871 8	0	222.1	222 1	44.5	32.6	189 5	102.2	11.9	90.3
	Digested	6659 4	633.4	3272 1	2638 7	751 5	688 1	1950 6	880.8	63 4	817.4
	Per cent digested	88.4	100.0	93.6	92.2	94.4	95.5	91.1	89.6	84.2	90.0

SHEEP NO. 4.

Number.		Total Dry Matter.	Total Sugars.	Nitrogen-free Extract.	N-free Extract, less Sugars.	Total Pentosans.	Pentosans in N-free Extract.	N-free Extract less Pentosans and Sugars in it.	Crude Fiber.	Pentosans in Crude Fiber.	Crude Fiber less Pentosans in it.
819	Green rape No. I fed	7543.2	633.4	3500.8	......	797.2	......	......	985.1	75.4	......
823	Waste rape	78.2	6.2	24 5	......	8 0	......	......	10 5	.8	......
	Consumed	7465.0	627.2	3476.3	2849.1	789.2	714.6	2134 5	974.6	74 6	900.0
912	Excrement	852.2	0	208.3	208 3	40.7	29.5	178.8	93 8	11.2	82.6
	Digested	6612 8	627.2	3268 0	2640 8	748.5	685.1	1955 7	880.8	63.4	817.4
	Per cent digested	88.6	100 0	94 0	92.7	94 8	95 9	91.6	90.4	84.9	90 8
	Mean per cent digested	88.5	100.0	93.8	92.5	94 6	95.7	91.4	90 0	84.6	90.4

* (See Table No. V, Bulletin 160.)

TABLE XIV.—*Continued.*

SHEEP NO. 1.

Number.		Total Dry Matter.	Total Sugars.	Nitrogen-free Extract.	N-Free Extract less Sugars.	Total Pentosans.	Pentosans in N-Free Extract.	N-Free Extract less Pentosans and Sugars in it.	Crude Fiber.	Pentosans in Crude Fiber.	Crude Fiber less Pentosans in it.
820	Green rape No. II fed	9893.0	695.5	4213.4	......	861.7	....	......	1043.7	66.3	....
822	Waste rape	225.6	15.9	64.6	..	19.7	...	.....	25.7	1.5	...
	Consumed	9667.4	679.6	4148.8	3469.2	842.0	777.2	2692.0	1018.0	64.8	953.2
910	Excrement	1774.3	0	388.4	388.4	68.1	53.0	335.4	165.9	15.1	150.8
	Digested	7893.1	679.6	3760.4	3080.8	773.9	724.2	2356.6	852.1	49.7	802.4
	Per cent digested	87.7	100	90.6	88.8	91.8	93.2	87.5	83.7	76.7	84.2

SHEEP NO. 2.

Number.		Total Dry Matter.	Total Sugars.	Nitrogen-free Extract.	N-Free Extract less Sugars.	Total Pentosans.	Pentosans in N-Free Extract.	N-Free Extract less Pentosans and Sugars in it.	Crude Fiber.	Pentosans in Crude Fiber.	Crude Fiber less Pentosans in it.
820	Green rape No. II fed	9893.0	695.5	4213.4	......	861.7	......	....	1043.7	66.3	......
821	Waste rape	368.4	25.9	123.5	....	32.1	......	......	52.2	2.5	......
	Consumed	9524.6	669.6	4089.9	3420.3	829.6	765.8	2654.5	991.5	63.8	927.7
911	Excrement	1866.3	0	444.1	444.4	67.4	51.5	342.9	156.4	15.9	140.5
	Digested	7658.3	669.6	3645.5	2975.9	762.2	714.3	2267.6	835.1	47.9	787.2
	Per cent digested	80.4	100	89.2	87.0	91.9	93.2	85.5	84.2	75.1	84.9
	Mean per cent digested	81.0	100	89.2	87.9	91.9	93.2	86.5	84.0	75.9	84.6

TABLE XV.—*Nutrients Consumed and Excreted in Grams, with Percentages Digested.*

SHEEP NO. 1.

Number.		Total Dry Matter.	Total Sugars.	Nitrogen-free Extract.	N-free Extract, less Sugars.	Total Pentosans.	Pentosans in N free Extract.	N free Extract less Pentosans and Sugars in it.	Crude Fiber.	Pentosans in Crude Fiber.	Crude Fiber less Pentosans in it.
753	Crabgrass hay No. I fed	4019.7	76.5	1830.1	......	1063.0	......	......	......	195.6	......
917	Rice bran fed	4074.2	63.6	2108.4	......	443.3	......	......	......	40.7	......
918	Waste bran	912.7	14.2	471.5	......	99.3	......	......	......	9.1	......
919	Waste hay	525.0	9.9	264.2	......	137.8	......	......	......	25.3	......
	Consumed in hay	3524.7	66.6	1565.9	1499.3	925.2	754.9	744.4	1314.1	170.3	1173.8
	Consumed in bran	3161.5	49.4	1636.9	1587.5	344.0	312.4	1275.1	369.4	31.6	337.8
	Total consumed	6686.2	116.0	3202.8	2086.8	1269.2	1067.3	2019.5	1713.5	201.9	1511.6
	Solid excrement	2650.0	0	1070.3	1070.3	463.2	393.5	676.8	690.9	69.7	621.2
914	Digested	4063.2	116.0	2132.5	2016.5	806.0	673.8	1342.7	1022.6	132.2	890.4
	Digested from hay	......	66.6	778.3	711.7	583.8	464.6	247.1	904.6	119.2	785.4
	Digested from bran	......	49.4	1354.2	1304.8	222.2	209.2	1095.6	118.0	13.0	105.0
	Per cent ration digested	......	100.	66.6	65.3	63.5	63.1	66.5	59.7	65.5	58.9
	Per cent bran digested	......	100	82.7	82.2	64.5	66.9	85.9	32.0	41.1	31.1

(See Table No. V, Bulletin 160.)

TABLE XV.—*Continued.*

SHEEP NO. 2.

Number.		Total Dry Matter.	Total Sugars.	Nitrogen-free Extract.	N-Free Extract less Sugars.	Total Pentosans.	Pentosans in N-Free Extract.	N-Free Extract less Pentosans and Sugars in it.	Crude Fiber.	Pentosans in Crude Fiber.	Crude Fiber less Pentosans in it.
753	Crab grass hay No. I fed	4049.7	76.5	1830.1	1753.7	1063.0	867.4	886.2	1504.5	195.6	-------
917	Rice bran fed	4074.2	63.6	2108.4	2044.8	443.3	403.6	1642.2	493.0	40.7	-------
	Fed and consumed	4123.9	140.1	3938.5	3798.4	1506.3	1270.0	2528.4	1997.5	236.3	1761.2
915	Solid excrement	3332.9	0	1371.5	1371.5	643.6	537.6	833.9	950.2	106.0	844.2
	Digested	4791.0	140.1	2567.0	2426.9	862.7	732.4	1684.5	1047.3	130.3	817.0
	Digested from hay	2263.3	76.5	919.6	843.1	670.7	540.4	302.7	1012.5	136.7	875.8
	Digested from bran	2567.7	63.6	1647.4	1583.8	192.0	192.0	1381.8	34.8	-------	-------
	Per cent ration digested	59.0	100	65.2	63.9	57.3	57.7	66.6	52.4	55.1	46.3
	Per cent bran digested	63.0	100	78.1	77.5	43.3	47.7	84.1	7.1	-------	-------
	Mean per cent ration digested	59.7	100	65.9	64.6	60.4	60.4	66.6	55.8	60.3	52.6
	Mean per cent bran digested	64.7	100	80.4	79.9	53.5	57.3	85.0	19.1	-------	-------

TABLE XVI.—* *Nutrients Consumed and Excreted, with Percentages Digested.*

SHEEP NO. 3.

Number.		Total Dry Matter.	Total Sugars.	Nitrogen-free Extract.	N-Free Extract less Sugars.	Total Pentosans.	Pentosans in N-Free Extract.	N-Free Extract less Pentosans and Sugars in it.	Crude Fiber.	Pentosans in Crude Fiber.	Crude Fiber less Pentosans in it.
1412	Timothy hay No. II fed	4547.8	241.0	2283 1	......	1195.6	......	......	1700.3	244.7	......
1413	Waste hay	48 3	2.6	23.9	......	11 5	......	......	17.7	2.6	......
	Consumed	4499 5	239.4	2259.2	2019 8	1184.1	942.0	1077.8	1682 6	242.1	1440.5
1410	Solid excrement	2120.7	0	960 6	960 6	504 9	394 6	566.0	750.5	110.3	640.2
	Digested	2378 8	239 4	1298.6	1059.2	679 2	547.4	511.8	932.1	131 8	800.3
	Per cent digested	52 8	100	57.5	52.4	57.4	58 1	47.5	55.4	54.4	55 6

SHEEP NO 4.

Number.		Total Dry Matter.	Total Sugars.	Nitrogen-free Extract.	N-Free Extract less Sugars.	Total Pentosans.	Pentosans in N-Free Extract.	N-Free Extract less Pentosans and Sugars in it.	Crude Fiber.	Pentosans in Crude Fiber.	Crude Fiber less Pentosans in it.
1412	Timothy hay No. II fed	4547 8	241 0	2283.1	......	1195 6	......	......	1700 3	244.7	......
	Waste	4 5	.2	2.3	......	1 1	...	......	1 6	.2	......
	Consumed	4543.3	240 8	2280.8	2040.0	1194 5	950 0	1090 0	1698 7	244 5	1454.2
1411	Solid excrement	2285 3	0	1026 0	1026.0	543.5	420 1	605 9	812 7	123.4	689.3
	Digested	2258 0	240 8	1254 8	1014 0	651 2	529 9	484 1	886 0	121.1	764 9
	Per cent digested	49 7	100	55 0	49.7	54.4	55 8	44.4	52.2	49 5	52.6
	Mean per cent digested	51.3	100	56.2	51 1	55.9	57.0	46 0	53 8	52 0	54 1

*Details not yet published.

BULLETIN NO. 173 JUNE, 1900

THE NORTH CAROLINA

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

AGRICULTURAL EXPERIMENT STATION DEPARTMENT

GEO. T. WINSTON, A.M., LL.D., DIRECTOR.

Another Warning in Regard to Compost Peddlers.

W. A. WITHERS.

WEST RALEIGH, N. C.

THE NORTH CAROLINA COLLEGE OF AGRICULTURE AND MECHANIC ARTS

AGRICULTURAL EXPERIMENT STATION DEPARTMENT,

WEST RALEIGH, N. C.

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The Director's office is in the main building of the College. Telephone No. 38. The street cars pass within one hundred yards of the College building.

The Station is glad to receive any inquiries on agricultural subjects. *Address all communications to the Agricultural Experiment Station, and not to individuals.* They will be referred to the members of the Station staff most competent to answer them.

Another Warning in Regard to Compost Peddlers.

W. A. WITHERS, A.M. CHEMIST.

In January, 1897, the Experiment Station published a bulletin (No. 137) regarding compost peddlers, in which the following language was used:

"The farmers of the State are urgently advised not to pay any money for fertilizing formulas, as the Station is ready and willing to suggest any mixture for any crop, using any materials at hand, or most convenient to be had. It has in the past distributed many hundreds of these formulas, and is distributing them every day. These formulas are sent entirely free, and are made up in proportions that are known to be correct, not only from a scientific but a practical standpoint. Of what earthly use is it to buy from a man, at a high price, a set of figures, which nine times out of ten, is incorrect, and even if correct, could be had by application to the Station without cost? * * * After an experience of twenty years, the Station can confidently advise the people of the State to stop buying so-called formulas that are in almost all cases entirely worthless."

The purpose of this bulletin is to repeat the warning given three years ago and to emphasize it by pointing out the defects in two such formulas which have been offered for sale in the State.

One of these formulas reads as follows:

"*Home Fertilizer*

RECEIPT PRICE $5.00.

The greatest fertilizer known for the farmer. Results much better from using the Home Fertilizer than any other made.

COST $3.00 *PER TON.*

Box to hold one ton four feet square.

INGREDIENTS.

No. 1. Stable Manure 1 inch thick.
" 2. Chemicals One Gallon on Layer.
" 3. Lime one-eighth of an inch thick.
" 4. New dirt one inch thick.
" 5. Ashes one half of an inch thick.
" 6. Salt 60 pounds to ton.

Chemical Preparation for one Ton.

Potash, 8 lbs; Nitrate of Soda, 4 lbs; Coperas, 4 lbs; Muriate of Ammonia, 12 lbs; Phosphate Acid, 5 lbs. Mix with 12 gallons warm water.

....Agent."

The name of the author is not given, but at the bottom of the formula is written, "John Green, Agent, from Sullivan County, Tenn."

It will be noted that the quantities of the ingredients to be used are expressed in some instances in pounds, in others in gallons, and in still others are to be determined by the thicknesses of layers in a box four by four feet. Knowing the weight of a gallon of water, estimating the cubical contents of the layers of different thicknesses, calculating to the equivalent in bushels and knowing the weights per bushel of the ingredients, the quantities of which are expressed in layers, we find that to make one ton it will take about nine layers of each ingredient and the box 4x4 feet to hold it should be a little over two feet deep.

One ton of the "Home Fertilizer" would be made up approximately of the following ingredients:

No. 1.	558 lbs.	Stable manure.	
No. 2.	8 lbs.	Potash.	Chemicals.
	4 lbs.	Nitrate of soda.	
	4 lbs.	"Coperas."	
	12 lbs.	Muriate of ammonia.	
	5 lbs.	"Phosphate acid."	
	98 lbs.	Warm water.	
No. 3.	81 lbs.	Lime.	
No. 4.	927 lbs.	New dirt.	
No. 5.	243 lbs.	Ashes.	
No. 6.	60 lbs.	Salt.	
	2,000 lbs.	Total.	

Some of these ingredients call for special mention:

The substance acid phosphate, or superphosphate, is in common use for fertilizing purposes, and phosphoric acid is also known to the chemist, but there is no such substance as "*phosphate acid,*" and consequently, it is impossible for the farmer to purchase it.

Muriate of ammonia is not used for fertilizing purposes and is not licensed for sale in the State for such purposes. The only portion of it which is of value to plants is nitrogen, and it can be obtained more cheaply in the form of sulphate of ammonia, nitrate of soda, or organic substances. The directions for making "Home Fertilizer" are to mix the chemicals with warm water. Under these circumstances the ammonia will be set free by the potash and be lost.

Copperas (which is spelled in the formula of "Home Fertilizer" "coperas"), has been used upon experimental plots and found to be of no value in promoting plant growth.

Nitrate of Soda is valuable to plants when enough is used. In the

"Home Fertilizer" only four pounds per ton of compost are used, and this quantity is too small to be of any value. The nitrogen in four pounds of nitrate of soda would be furnished by about three dead cats and three dead cats to an acre would not help the plants very much.

Commercial *potash* is a mixture of potassium carbonate, caustic potash and caustic soda. It is not used for fertilizing purposes and is not licensed for sale for such purposes. It is objectionable because, on account of its caustic properties, it would tend to set ammonia free, and because the fertilizing element which it furnishes can be obtained more cheaply from the potash salts which are found upon the market. The actual potash in four pounds of commercial potash could be obtained from one bushel of ashes.

Lime is of value on some soils, but when used it is best to apply it directly to the soil at the rate of one ton or more per acre. In the compost heap it sometimes aids and sometimes checks fermentation. Its value in the compost heap is questionable, and it is not recommended for such use by the leading authorities.

Salt does not furnish any element which is needed by the plant, and it is of no value in the compost heap. Many years ago it was used in the compost heap with lime, but it is no longer used in that way, as it is considered to be of no benefit.

Nearly one-half of a ton of "Home Fertilizer" is *new dirt*. The only object in using new dirt in a compost heap is to catch any ammonia which might otherwise be lost. For this purpose small quantities are sufficient. When large quantities of new dirt are used the fertilizing strength of the compost is weakened and a large amount of unnecessary labor in handling is involved.

The two remaining ingredients are *stable manure* and *ashes*. Surely there are very few farmers who do not know that these substances are valuable if properly handled. In "Home Fertilizer" the proportions given for mixing these two substances are such that very much less good is accomplished by them than is possible because these substances do not contain their fertilizing ingredients in the best proportions to meet the needs of the growing plant. One thousand pounds of stable manure contain about 2.5 pounds of phosphoric acid, 5 pounds nitrogen and 6 pounds of potash. The amount of phosphoric acid in stable manure in comparison with the nitrogen and potash is not sufficient to meet the needs of the plant; consequently acid phosphate should be added. One thousand pounds of ashes contain about 20 pounds of phosphoric acid, no nitrogen, and 60 pounds of potash. To ashes, therefore, should be added materials supplying phosphoric acid and nitrogen. When stable manure and ashes are used there is a deficiency of both phosphoric acid and nitrogen and, consequently, materials should be

added supplying these. Unless this is done there is either too much potash or an insufficiency of phosphoric acid and nitrogen, which will result in waste in one case or a poor crop in the other.

It is claimed by the originator that "*results* (are) *much better from using the Home Fertilizer than any other made.*" The value of a fertilizer depends upon the amount of phosphoric acid, nitrogen and potash present in forms available to plants. Upon this basis let us compare "Home Fertilizer with the ordinary commercial fertilizer. One ton of the average commercial fertilizer sold in North Carolina (see Bulletin No. 158, page 89) contains about 170 pounds of available phosphoric acid, 50 pounds of nitrogen, and 45 pounds of potash. One ton of "Home Fertilizer" contains about 7 pounds of phosphoric acid, 6 pounds of nitrogen and 22 pounds of potash. It would take, therefore, over two tons of "Home Fertilizer" to furnish the amount of potash in one ton of average commercial fertilizer, over eight tons to furnish the nitrogen and over twenty-four tons to furnish the phosphoric acid. The claim made for "Home Fertilizer" has, therefore, no foundation in fact, and is an exaggeration which cannot be justified even for advertising purposes.

We advise farmers not to purchase the formula for making "Home Fertilizer."

ANOTHER FORMULA TO BEWARE OF.

The following is a reproduction, as to type, wording and spelling, of a process offered for sale in the State, and which the Experiment Station warns farmers against purchasing or using:

"*The Process

OF COMPOUNDING THE FARMERS'

COMPOUND FERTILIZER.

First dig in each stable a pit size of stall or stable three feet deep. After digging the pit take rich, loamy soil or swamp muck. After being good and dry place in the pit to the depth of six inches, then place a thin layer of tobacco stalks, rotten straw or cotton seed. Then apply liberally by hand over the entire surface of the pit, the following compound or mixture: Twenty-five lbs. of salt petre, one bushel of common salt and one quart of carbolic acid, one gallon on each layer of the rich soil. Then dilute the carbolic acid in ten times the amount of water and sprinkle each layer. Then fill in another layer of rich soil and straw, and apply another sprinkle of the compound, and continue as above stated six inches of loam and another sprinkle of compound until the pit is filled to the surface of the ground. Then floor the stall or stable by laying small poles on the compound and floor the stable. The stock should be kept in the stall six months. The drainage of the stock and stall adds a great deal to the compound. This is the single process of compounding the Farmers' Compound Fertilizer.

Then construct alongside of stables a pen or pens with water tight floor, slanting downward. Place a V trough by the side of pens to catch the contents of said pen and run off in a barrel. Fill the pens with barn yard, chip manure, tobacco stalks or any rubish, leave the pens uncovered. Construct by trough, the water from eaves of barn or stables, into the pens. Care should be taken not to let too much water go in the pens. Thus you have a complete leaching system. When the barrels are filled with lye from the pens it should be poured in stall or stable and sink into the pit with the compound. This is the double process of manufacturing Farmers' Compound Fertilizer.

STOCK IN THE STALL IS A GOOD CONDUCTOR OF

Amonia from the air. Established by which the amonia Phosphoric acid and Potash from the solid manure, is conducted into the pit under the stall or stables and is there joined by the same ingredients in a safer and more abundant form, from the liquid manure deposited by the stock; making a powerful and available plant food in a much more concentrated and available form than is found in high priced commercial fertilizers.

At the end of six months your pits are ready to throw out, the contents of which has by this time become as black as ink and strong as lye. If you now want to use this through a drill it will be necessary to dry by spreading thinly on barn lot or floor and run through a sieve, or what is better, if you

*Above these words on the original is a wood-cut over the words "Col. I. J. Britain, Inventor, Winston, N. C.," which we deem unnecessary to produce.

have one, an old fanning mill. If you wish to use in the drill on any crop when a drill is not necessary the drying sieving may be dispensed with.

An ordinary stable, say 10x14 feet will furnish 200 bushels of the compound, sufficient to fertilize 20,000 hills of tobacco or twenty acres of wheat with the highest grade fertilizer known to science.

The public is warned not to infringe upon my invention unless they are authorized by myself or lawful agents, for my rights must be respected.

COPY IGHT SECURED.

I. J. BRITAIN, WINSTON, N. C."

We object to this formula because some of the statements are questionable as to accuracy, the directions are not sufficiently explicit, the process itself involves waste of labor and loss of material. We also advise farmers not to purchase formulas for making composts, because better formulas can be obtained free of charge.

The objectionable points may be treated more especially under the following heads:

QUESTIONABLE STATEMENTS.

(1) The statement in the "Process," etc., that "stock in the stall is a good conductor of amonia (ammonia) from the air" is not true.

(2) The statements in the "Process," etc., that the mixture gives "a powerful and available plant food in a much more concentrated and available form than is found in high-priced fertilizers," and that the mixture is "the highest grade fertilizer known to science," are not true.

(3) It is stated on the sheet, "copyright secured," but in answer to a letter of inquiry, the Librarian of Congress in Washington writes us that the indexes "do not show any entry of copyright of the process of compounding the Farmers' Compound Fertilizer by I. J. Britain."

DIRECTIONS NOT SUFFICIENTLY EXPLICIT.

(4) The directions are to "place a thin layer of tobacco stalks, rotten straw or cotton seed," but we are not told how many inches or what fraction of an inch corresponds to "thin."

(5) The method prescribed for the application of carbolic acid is not clear. In one place the directions are to mix with saltpetre and common salt, and in the very next sentence we are told to dissolve it in water and sprinkle it over the layer. Which method shall be followed?

(6) We are warned that "care should be taken not to let too much water go in the pens," but we are not given any rule for telling what amount is "too much."

(7) No directions are given as to the length, breadth or depth of a pen to correspond with a stable 10 x 14 feet.

(8) What does the author mean when he says: "Established by which the amonia phosphoric acid and potash," etc?

DIRECTIONS INVOLVING UNNECESSARY LABOR OR WASTE OF MATERIAL.

(9) The process involves the use of 25 pounds of saltpetre. This substance furnishes potash and nitrogen. Potash can be obtained more cheaply in the ordinary potash salts, and nitrogen can be obtained more cheaply in the form of nitrate of soda, sulphate of ammonia or some organic substance.

(10) The process involves the use of one bushel of common salt which is of no value to plant growth.

(11) The process involves the use of carbolic acid which is not beneficial to plant growth, but which on the contrary has been known to hinder the germination of seeds.

(12) The process involves the digging of a pit, the construction of a floor in the stable with poles, the building of a pen with a water-tight floor, the throwing up into the pens of barnyard manure, etc., and the pouring of manure water from barrels into the stables. A very large part of this is unnecessary and therefore wasteful of labor.

(13) The process does not provide for saving the manure after it is leached in the pens. This substance is of some value and the farmer can not afford to throw it away.

When the farmer counts up the cost of the labor involved, and of the material used and considers that the only thing possible to be accomplished is the saving of about four or five thousand pounds of stable manure (dropped in each stable during six months), worth in the stable only four or five dollars, and that without any precaution some of the material would be saved anyway, he will doubtless conclude that "the process of compounding the Farmer's Compound Fertilizer" will prove a loss to him instead of a profit.

SUMMARY.

The two formulas which have been discussed above are typical of those which are usually offered for sale. We most earnestly advise farmers not to purchase compost formulas from travelling agents because they are either worthless, wasteful of labor, or material, or they prescribe substances which are not known or which are more expensive than necessary, and because the State has provided already means for furnishing free of cost to farmers formulas for making composts, mixtures, etc. At the end of this Bulletin is a list of Bulletins which can be had free of charge, and which give directions in full in regard to composts, etc. We give also a list of standard books

which this Station can recommend as reliable and as based on actual experience in the field and stable. In addition to this the members of the staff of this Experiment Station are glad to communicate with the farmers of the State in regard to matters which may perplex them, and about which they desire information.

We especially ask that a report be made to us of any compost peddler who is endeavoring to sell his formulas or so-called farm rights throughout the State.

PUBLICATIONS RELATING TO FERTILIZERS.

EXPERIMENT STATION BULLETINS.

No. 137.—A warning in regard to compost peddlers.
No. 139.—Homemade fertilizers and composts.
No. 159.—Horticultural Experiments at Southern Pines.

These may be obtained free of charge upon application to the Director of the Agricultural Experiment Station Department of the N. C. College of Agriculture and Mechanic Arts, West Raleigh, N. C.

FARMERS' BULLETINS.

No. 21.—Barnyard Manure.
No. 36.—Cotton Seed and Its Products.
No. 44.—Commercial Fertilizers and Composts.
No. 48.—Manuring of Cotton.
No. 77.—Liming of Soils.
No. 81.—Corn Culture in the South.
No. 82.—Culture of Tobacco.
No. 89.—Cowpeas.

These may be obtained free of charge upon application to the Secretary of Agriculture, Washington, D. C.

STANDARD BOOKS.

The Fertility of Land, by Roberts, 421 pages, published by the MacMillan Co., New York, N. Y., price $1.25.

Fertilizers, by Voorhees, 335 pages, published by the MacMillan Co., New York, N. Y.; price $1.00.

The Chemistry of Soils and Fertilizers, by Snyder, 277 pages, published by the Chemical Publishing Co., Easton, Pa.; price $1.50.

Agriculture in some of its Relations with Chemistry, by Storer, 3 volumes, 1901 pages, published by Charles Scribner's Sons, New York, N. Y.; price $5.00.

These should be ordered directly from the publishers or through a local book dealer.

BULLETIN NO. 174 JUNE, 1900

THE NORTH CAROLINA

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

AGRICULTURAL EXPERIMENT STATION DEPARTMENT

GEO. T. WINSTON, LL.D., DIRECTOR.

Methods of Determining Proteid Nitrogen in Vegetable Materials.

G. S FRAPS AND J A. BIZZELL

WEST RALEIGH, N. C

THE NORTH CAROLINA COLLEGE OF AGRICULTURE AND MECHANIC ARTS

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The Station is glad to receive any inquiries on agricultural subjects. *Address all communications to the Agricultural Experiment Station, and not to individuals.* They will be referred to the members of the Station staff most competent to answer them.

Methods of Determining Proteid Nitrogen in Vegetable Materials.

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The method usually used for the determination of proteid nitrogen, is that modification of the Ritthausen method proposed by A. Stutzer,(*a*) which consists in precipitating the proteids with copper hydroxid, and determining the nitrogen in the precipitate. This method has been adopted by the Association of Official Agricultural Chemists, and is in use by chemists generally.

Mallet(*b*) has recently proposed that the proteids be precipitated with phospho-tungstic acid at 90 degrees C., using in addition tannic acid when peptones are present.

Wiley(*a*) determines the proteids in animal materials by precipitating them with bromin.

The work here to be described is a study of the applicability of the phospho-tungstic acid and bromin as precipitants for the proteids of vegetable materials.

THE PHOSPHO-TUNGSTIC ACID METHOD.

The method as proposed by Mallet(*b*) is, briefly, as follows: The sample is digested with hot water, filtered on a nitrogen-free filter, and washed with hot water containing a little free acid so long as it gives up soluble matter in sensible amount. It is not advisable to use hot water at first when much starch is present. The filtrate is made slightly acid with acetic acid, heated to about 90 degrees, and filtered. To the second filtrate an acidified solution of phospho-tungstic acid is added so long as a precipitate continues to be formed, avoiding any large excess of reagent, the liquid heated to about 90 degrees, filtered and the precipitate washed with water of about the same temperature. The nitrogen in the precipitates is determined by the Gunning-Kjeldahl method, and calculated to proteids. When peptones are present they are precipitated with tannic acid from the solution which has been acidified with acetic acid. When proteoses are present it may be well to make a check determination of their amount by saturation of the aqueous solution, after acidification with acetic acid, heating and subsequent cooling, with zinc sulfate, and determining nitrogen in the precipitate. It may be well to remove fat when it is present in large quantity.

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a Jour. f. Landw., 28, 103.
b Bulletin 54, Division of Chemistry, U. S. Dept. of Agr.

METHOD MODIFIED.

The method above described involves three, or, if peptones are present, four filtrations, which make it very long and tedious. The object of the precipitation with acetic acid is to reduce the bulk of the subsequent phospho-tungstic acid precipitate, out of which the amids are to be dissolved by hot water. Its use is unnecessary. When the above method was followed it was found impossible to get a clear filtrate from most of the vegetable materials tested, although various modifications were tried. At 60 degrees, however, no such difficulty was encountered, although at a slightly higher temperature—depending on the material—turbidity would begin to appear. It was also found that between 60 degrees and 100 degrees, a considerable portion of the nitrogen goes into solution. For this reason the temperatures of 60 degrees and 100 degrees were selected for further tests, 100 degrees giving the maximum turbidity and minimum amount of nitrogen, 60 degrees the minimum of turbidity. The method after much experimentation was simplified as follows: 1.4 grams of the substance in a beaker were stirred well with 100 cc. water, the phospho-tungstic acid reagent added, and the liquid heated. The liquid was kept at the desired temperature (60 or 100 degrees) for fifteen minutes, filtered, the precipitate washed with water at the same temperature, and nitrogen determined in it.

The reagent used was a 5 per cent solution of phospho-tungstic acid in 2.5 per cent hydrochloric acid; 5 cc. were used for 3 per cent or less of nitrogen, 10 cc. for 6 per cent, and 15 cc. for 9 per cent.

EFFECT OF REAGENT.

In dealing with vegetable materials it was found impossible to tell when a slight excess of the phospho-tungstic acid reagent had been added. The following results were obtained by using different quantities of the reagent, and heating to 60 degrees. The figures are means of two closely agreeing determinations.

No. 1. Cotton-seed meal.

10 cc. reagent	6.61 per cent nitrogen.
30 " "	6.64 " "
50 " "	6.27 " "

No. 2. Wheat bran.

5 cc. reagent	2.07 per cent nitrogen.
10 " "	2.08 " "
25 " "	2.11 " "
45 " "	2.09 " "

No. 3. Cowpea meal.

5 cc. reagent	3.18 per cent nitrogen.
10 " "	3.11 " "
25 " "	3.22 " "
45 " "	3.17 " "

A small excess of reagent does not affect the results. A very large excess affects them in the case of cotton-seed meal. It seems that 5 cc. of the reagent is sufficient for any vegetable material containing less than 3 per cent of nitrogen, 10 cc. for 6.5 per cent, and 15 cc. for 9 per cent.

EFFECT OF TEMPERATURE.

As has already been stated, a clear filtrate could not as a rule be obtained at a temperature much over 60 degrees, and nitrogen goes into solution between 60 degrees and 100 degrees. In cotton-seed meal and wheat bran, the greatest amount of solution takes place between 75 degrees and 90 degrees; cotton-seed meal gave at 60 degrees, 6.61 per cent nitrogen; at 75 degrees, 6.58 per cent; at 90 degrees, 4.94 per cent; at 100 degrees, 4.22 per cent. Wheat bran at 60 degrees, gave 2.08 per cent nitrogen; at 75 degrees, 2.01 per cent; at 100 degrees, 1.75 per cent. The amount of nitrogen dissolved between 60 degrees and 75 degrees is very small.

In order to show the solvent action between 60 degrees and 100 degrees, the following figures are given: Of the nitrogen precipitated at 60 degrees, in cotton-seed meal (No. 1), 36 per cent goes into solution at 100 degrees; another sample (No. 2), 24 per cent; still another (No. 3), 21 per cent; cowpea-meal, 9 per cent; green peas, 7 per cent; soy beans, 18 per cent; horn-meal, 9 per cent; linseed-meal, 12 per cent; and dried blood, 47 per cent.

No.	Name of Material.	Nitrogen. 60° Phospho tungstic Acid Method.	Nitrogen. 100° Phospho tungstic Acid Method.	Difference.
		Per Cent.	*Per Cent.*	*Per Cent.*
1416	Cowpea Meal	3.18	2.88	0.30
1497	Cotton seed Meal, No. II	6.28	4.75	1.53
1498	Cotton seed Meal, No. III	6.48	4.99	1.49
1499	Green Peas	1.57	1.46	0.11
1500	Dried Blood	12.82	6.85	5.97
1501	Soy Beans	5.90	4.83	1.07
1502	Linseed Meal	2.74	2.42	0.32
1503	Horn Meal	13.50	12.21	1.29

Working with blood at 100 degrees, it was found that 5.97 per cent (37.31 per cent proteids) goes into solution between 60 degrees and 100 degrees. This sample of blood contained 13.66 per cent nitrogen, 13.39 per cent of it being insoluble in water. The filtrate from the 100 degrees phospho-tungstic acid method was clear, and remained clear although 5.97 per cent of proteid nitrogen was therein dissolved. This observation threw doubt upon the basis upon which the phospho-tungstic acid method is founded; namely, that the phos-

pho-tungstic acid precipitate with proteids is not soluble in hot water. This statement is based upon the observation that "the supernatant liquid remained clear on being heated along with the precipitate and subsequently cooled." The following experiments confirmed this suspicion, and proved that phospho-tungstic acid does not completely precipitate proteids at 90 degrees or 100 degrees.

0.35 grams of the materials named below were placed in a Kjeldahl flask, 100 cc. of water and 5 cc. of the phospho-tungstic acid reagent added, and the solution heated to 60 degrees. The solution was kept at this temperature for fifteen minutes, filtered, washed with water at the same temperature, and nitrogen determined in the precipitate by the Gunning method. Determinations were also conducted at 90 degrees and 100 degrees. Those at 90 degrees were conducted as the others except that the filtration was proceeded with as soon as that temperature was attained.

No.	Name of Material.	Total Nitrogen.	Nitrogen. 60° Phosphotungstic Acid Method.	Nitrogen. 90° Phospho tungstic Acid Method.	Nitrogen. 100° Phospho-tungstic Acid Method.
		Per Cent.	*Per Cent*	*Per Cent.*	*Per Cent.*
1528	Casein	14.12	14.24	13.24	13.34
1529	Blood Albumen.......	11.82	11.74	11.26	9.92
1530	Egg Albumen........	12.42	12.58	12.38	11.90
1531	Hæmoglobin	13.40	12.82	11.28	9.20
1532	Blood Fibrin	13.94	13.62	......	12.60
1533	Gelatin	14.98	....	12.90	11.52

It will be noted that in every case the proteid precipitate was partially dissolved when it was heated. The phospho-tungstic acid reagent therefore is of no value for precipitating proteids at 90 degrees or 100 degrees. At 60 degrees—excepting gelatin, and perhaps haemoglobin, the proteids seem to be completely precipitated.

COMPARISON OF THE MODIFIED PHOSPHO-TUNGSTIC ACID AND THE STUTZER METHODS.

The 60 degrees phospho-tungstic acid method has already been described. The following table contains some results obtained by this method together with determinations made by the Stutzer method. The figures are means of two determinations.

No.	Name of Material.	Total Nitrogen.	Nitrogen. 60° Phospho tungstic Acid Method.	Nitrogen. Stutzer Method.
		Per Cent.	*Per Cent.*	*Per Cent.*
1415	Wheat Bran	2.20	2.07	1.79
1416	Cowpea-Meal	3.32	3.18	3.19
1417	Corn Bran	1.54	1.48	1.38
1426	Waste Rape	3.57	2.32	2.62
1496	Cotton-seed Meal, No. I	6.80	6.61	6.51
1497	Cotton-seed Meal, No. II	6.18	6.24	6.17
1498	Cotton-seed Meal, No. III	6.62	6.48	6.42
1499	Green Peas	1.76	1.57	1.45
1500	Dried Blood	13.66	12.82	13.00
1501	Soy Beans	6.15	5.90	5.97
1502	Linseed Meal	2.86	2.74	2.62
1503	Horn Meal	14.70	13.50	13.00

It will be noted that this method gives results which are, as a rule, almost identical with those by the Stutzer method, although slightly higher. The mean difference is 0.06 per cent, with a maximum of 0.50 per cent, and a minimum of —0.30 per cent. Neither method gives good results with blood; the filtrate from blood by the 60 degrees phospho-tungstic acid method contained 0.57 per cent water insoluble nitrogen, and gave a reaction (with copper sulfate and caustic soda) for proteids, and the copper hydroxid dissolved 0.39 per cent of water insoluble protein. With regard to the other materials it is impossible to say which method is correct. The 60 degree method promises, however, to be of value. It is possible that the determination might be carried on at a slightly higher temperature than this, but hardly over 80 degrees in any case.

PRECIPITATION WITH ZINC SULFATE.

A comparison was made between the nitrogen precipitated by zinc sulfate and that by the other methods on a few materials. The method was as follows: 1.4 grams of the substance were heated with 100 cc. of water to boiling, allowed to cool, 2 cc. of dilute sulfuric acid (1.4) added, and 140 grams crystalized zinc sulfate. It was allowed to stand a day or more, with frequent stirring, filtered, and

washed with a saturated solution of zinc sulfate containing 1 cc. of the dilute acid in 50 cc.

No.	Name of Material	Nitrogen. Insoluble in Zinc Sulphate.	Nitrogen. 60° Phosphotungstic Acid Method.	Nitrogen. Stutzer Method.
		Per Cent	*Per Cent.*	*Per Cent.*
1493	Cotton-seed Meal, No. I	6.45	6.61	6.51
1416	Cowpea-Meal	3.26	3.18	3.19
1500	Dried Blood	13.48	12.82	13.00
1501	Soy Beans	6.07	5.90	5.97

The results are higher than by the other methods in three of the four cases, and seem to point to the Stutzer method as being more nearly correct.

EXTRACTION OF WATER SOLUBLE NITROGEN.

Extraction of a vegetable material with hot water sometimes gives discordant results, as was the case with cotton-seed meal. The extraction was performed as follows: 1.4 grams were placed in a beaker with 50 cc. water, stirred well, and allowed to stand one hour. The liquid was decanted through a filter, 50 cc. water added to the residue in the beaker heated to boiling, filtered, and the residue washed with boiling water. The undissolved nitrogen was, in case (*a*) 4.54 and 4.68 per cent, mean 4.61 per cent; in case (*b*) (six months later) 4.12 and 4.22 per cent, mean 4.17 per cent; and case (*c*) (volume of filtrates less than in case *b*) 5.55 and 5.67 per cent mean 5.61 per cent. There is thus a variation of 1.44 per cent of nitrogen, or 9 per cent of protein.

It is quite possible that had the extracting water been slightly acid the results would have been more uniform.

THE BROMIN METHOD.

Rideal and Stewart(*a*) have proposed to use bromin as a precipitant for gelatin. Allen and Searle(*b*) applied the method to the analysis of meat extract. Wiley(*c*) has proposed the following method for the determination of proteids in animal matters. About one gram of the dried animal matter is washed with ether by decantation, using from 50 cc. to 100 cc. ether, and decanting through a filter which is to receive the portion insoluble in hot water. After allowing the

(*a*) Analyst: *22*, 228.
(*b*) Analyst: *22*, 258.
(*c*) Bulletin 54, Division of Chemistry, U. S. Dept. of Agr.

ether to evaporate, the sample is washed by decantation first with cold water and then with hot water, the total filtrate being from 300 cc. to 400 cc. The undissolved residues are brought on the filter with the last portions of water and the nitrogen in the residue determined by the Gunning-Kjeldahl method. The filtrate from the insoluble portions is received in Kjeldahl flasks, acidulated with two or three drops of strong hydrochloric acid, and then about 2 cc. of liquid bromin are added and the contents of the flask shaken vigorously. Bromin is added until about $\frac{1}{2}$ cc. remains undissolved and the supernatant liquid is thoroughly saturated. After standing over night, it is filtered and washed bv decantation, the globule of bromin serving to saturate the wash water. The filter with the precipitate is returned to the flask in which precipitation has taken place, and the nitrogen therein determined by the Gunning method.

METHOD MODIFIED.

After some experimentation the method above described was modified for vegetable materials as follows: 200 cc. of water were added to 1.4 grams of the substance in a Kjeldahl flask, heated to boiling, and allowed to cool. It was then acidified with hydrochloric acid, and bromin added until a small globule remained undissolved, the liquid allowed to stand over night, filtered, and the precipitate washed by decantation, keeping the wash water saturated with bromin. The filter and precipitate were returned to the flask, and the nitrogen therein determined by the Kjeldahl method.

Lower results are obtained by this method than by extracting the material with hot water and precipitating the proteids in the filtrate with bromin.

No.	Name of Material.	Bromin N. (as above.)	Water Insol. N.	Bromin-N. Infiltrate.
		Per Cent.	*Per Cent*	*Per Cent.*
1423	Cattail Millet	1.10	1.11	0.11
1426	Waste Rape	1.84	1.98	0.17
1427	Sheep Excrement	2.13	2.56	0.07

The bromin insoluble nitrogen is less than the water insoluble. This must be caused by solution of the water insoluble compound by either bromin, or hydrochloric acid.

COMPARISON OF THE BROMIN AND THE STUTZER METHODS.

Proteid nitrogen was determined in a number of materials by the method just described, and the results compared with those obtained by the Stutzer method. The following table contains the results:

No.	Name of Material.	Nitrogen. Stutzer Method.	Nitrogen. Bromin Method.
		Per Cent	*Per Cent.*
1415	Wheat Bran	1.79	1.51
1416	Cowpea-Meal	3.19	2.53
1417	Corn Bran	1.38	1.11
1428	Corn Silage	0.68	0.67
1496	Cotton-seed Meal, No. I	6.51	5.40
1497	Cotton seed Meal, No. II	6.42	5.80
1500	Dried Blood	13.00	12.53
1501	Soy Beans	5.97	5.23
1502	Linseed Meal	2.62	2.37
1499	Green Peas	1.45	1.25
1426	Waste Rape	2.62	1.84
1423	Cattail Millet	1.34	1.10
1425	Crab-grass Hay	1.38	1.51
1427	Excrement	2.79	2.13

The bromin method is not applicable in the case of cotton-seed meal. In one case the meal was extracted with water, and the extract gave a precipitate which settled almost immediately and contained 0.51 per cent nitrogen. A duplicate determination gave a turbid liquid, which would not filter clear after standing over night, and when the precipitate finally settled it yielded only 0.10 per cent nitrogen. When the meal was treated directly with bromin a turbid liquid was formed which refused to filter clear and the precipitate contained varying amounts of nitrogen. The results by the bromin method with two exceptions, are lower than with the Stutzer or the phospho-tungstic acid methods. Until it has been proven that bromin precipitates all vegetable proteids quantitatively, which is doubtful, this method must be condemned.

THE STUTZER METHOD.

The Stutzer method used in this work is as follows: Place 0.7 grams of the substance in a beaker, add 100 cc. water, heat to boiling, or, in case of substances rich in starch, heat on the water bath 10 minutes; add a quantity of copper hydroxid mixture containing about 0.5 grams of the hydroxid; stir thoroughly, filter when cold, wash with cold water and without removing the precipitate from the filter, determine nitrogen, adding sufficient potassium sulfid solution to com-

* Bulletin 54, Division of Chemistry, U. S. Dept. of Agr.

pletely precipitate all copper and mercury. If the substance examined consists of seeds, or seed residues,or anything else rich in alkaline phosphates, add a few cubic centimeters of a concentrated solution of alum before adding the copper hydroxid, and mix well by stirring.

Several objections have been made to this method. It has been stated that, in some cases, working with a proteid alone, the copper compound underwent partial solution, a blue liquid being formed, although care had been taken to avoid the presence of free alkali. The proteids acting in this way were not named. Another objection has been founded on "the very slight solubility of the copper salts of some of the simpler amido-acids, especially leucin and glutamic acid; in a less degree the same statement applies to aspartic acid. Even at the temperature of boiling water the copper compounds of these substances are but very sparingly soluble, and if the liquid after digestion with cupric hydroxid, be filtered cold (*a*) the compounds in question will, if present, be almost certainly left on the filter along with the proteid material." (*b*).

Laszcynski (*c*) also states that copper hydroxid precipitates the albumen of wort and beer completely, but also partly precipitates the albumoses and amids.

The copper salt of leucin is soluble in 3045 parts of cold water and 1460 parts of boiling water. (Beilstein.) When 0.7 grams of the substance and 100 cc. of water are used, for any of this salt to remain on the filter, 0.033 grams must be present, or 0.026 grams of leucin (since it contains 19.5 per cent. copper), which would be 3.7 per cent. The copper salt of glutamic acid is soluble in 3400 parts of cold water and 400 parts of boiling water, and 0.029 grams must be present before any will separate from 100 cc. cold water, equal to 0.022 grams glutamic acid, or 3.1 per cent. The solvent action of wash water is left out of consideration.

When the material contains less than 3.7 per cent leucin, or 3.1 per cent of glutamic acid, there is no danger of the amid separating in the cold. But the limits are much higher than these. The solubilities above noted are for the pure salts in pure water. E. Schulze (*d*) emphasizes the fact that the copper salts of these amids are much more soluble when impurities are present. While the copper salts of aspartic acid and glutamic acid separate quickly from a pure solution, from a mixture of the two they separate very slowly, or not until the liquid has been evaporated.

It is probably better, however, to conduct the determination in a hot solution.

(*a*) Bulletin No. 46, Division of Chemistry, U. S. Dept. of Agr. (1895), p. 25.
(*b*) Bulletin 54, Division of Chemistry, U. S. Dept. of Agr.
(*c*) Analyst (abs): 24. 184.
(*d*) Landw. Versuch—Stat: 6, 220 (1880).

It has also been objected to this method, that albumoses are not precipitated. This objection might be overcome by the use of tannic acid to precipitate them. The tannic acid should be used after the precipitation with copper hydroxid. It is only in rare cases that its use would be necessary. Qualititative tests with tannic acid were made on the filtrates from cotton-seed meal, wheat bran, compea-meal, corn bran, cattail millet excrement from crabgrass hay, waste rape, excrement from waste rape, corn silage. A small precipitate was formed in all cases except with cattail millet and corn silage. The precipitate from cowpea-meal and corn bran dissolved when the liquid was heated, reappearing on cooling. A repetition of the experiment showed that the precipitate appeared sometimes, but not always, with the same material. A determination of nitrogen in the precipitate from cotton-seed meal gave 0.03 per cent, practically none.

Conclusions.

Phospho-tungstic acid does not precipitate proteids completely at 90 degrees or 100 degrees.

With phospho-tungstic acid as the precipitant, at 60 degrees, very nearly the same results are obtained on vegetable materials as by the Stutzer method.

Bromine is not a suitable precipitant for proteids in vegetable materials.

The Stutzer method seems to be the method least open to objections.

Acknowledgment is due Mr. H. W. Primrose, formerly Assistant Chemist, for assistance in the analytical work of this Bulletin.